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### A THEORY OF BANK CAPITAL

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### **ABSTRACT**

Banks can create liquidity because their deposits are fragile and prone to runs. Increased uncertainty can make deposits excessively fragile in which case there is a role for outside bank capital. Greater bank capital reduces liquidity creation by the bank but enables the bank to survive more often and avoid distress. A more subtle effect is that banks with different amounts of capital extract different amounts of repayment from borrowers. The optimal bank capital structure trades off the effects of bank capital on liquidity creation, the expected costs of bank distress, and the ease of forcing borrower repayment. The model can account for phenomena such as the decline in average bank capital in the United States over the last two centuries. It points to overlooked side-effects of policies such as regulatory capital requirements and deposit insurance.

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Does bank capital matter, and if so, what should its level be? This question has exercised economists, regulators, and bank managers. On the one hand, some suggest that bank capital structure is irrelevant in a full information, complete contract world, and to a first order of approximation, also in the more imperfect "real" world (see Miller (1995), for example). At the other extreme, economists appeal to the large literature on the high costs of equity issuance for industrial firms to argue that banks will have similar difficulties in issuing long term equity (see Stein (1998), for example), and greater bank capitalization will only be obtained at some cost. But bank assets and functions are not the same as those of industrial firms.<sup>1</sup> How do we know that they will face similar costs of issuance? And does capital really play the same role in banks as in industrial firms? What we really should do is to start by modeling the essential functions banks perform, and then ask what role capital plays. This will help us answer whether capital issued by banks should, in fact, be deemed "costly". Moreover, such a model of banking can then help us understand a variety of issues such as disintermediation, or the impact of regulations, better.

To analyze the role capital plays in the bank's activities, we start with the model of relationship lending in Diamond and Rajan (1999). A number of entrepreneurs have projects where the cash flows that each entrepreneur can generate from his project exceeds the value anyone else can generate from it. An entrepreneur cannot commit his human capital to the project, except in the spot market. Outside financiers can extract repayment only by threatening to liquidate the project (taking away the project from the entrepreneur and selling it to the next best user), but because of the entrepreneur's specific abilities, they can extract only a fraction of the cash flows generated. Thus projects are illiquid in that they cannot be financed to the full extent of the cash flows they generate.

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<sup>1</sup> In fact, one strand of the banking literature suggests banks have a role precisely because they reduce asymmetric information costs of issuance (see Gorton and Pennachi (1990)).

In this world, we assume an outside financier who invests at an early stage can develop specific abilities in that he can learn how best to re-deploy the project's assets, and become a relationship lender. While these specific abilities enable the relationship lender to lend more to the firm -- because the lender has a stronger threat with which to extract repayment -- they can make the financial claim he holds against the entrepreneur illiquid; The relationship lender will not be able to sell his loan (or equivalently, borrow against it) for anywhere near as much as the payments he expects to extract from the entrepreneur, precisely because he cannot commit to using his specific abilities on behalf of less capable outsiders. Thus the source of illiquidity of the real asset (the project) and the financial asset (the loan to it) are the same: an agent's specific abilities, which lead to non-pledgeable rents. In the case of the project, it is the entrepreneur's greater ability to run it relative to a second best operator, in the case of the loan it is the relationship lender's better ability to recover payments relative to someone who buys the loan (or lends against it).

The illiquidity of the financial asset spills over to the entrepreneur. Since the initial outside financier cannot borrow money against his loan when in need, he will liquidate the entrepreneur at such times, or demand an excessive liquidity premium.

Since an asset is illiquid because specialized human capital cannot be committed to it, devices that tie human capital to assets create liquidity. We show in Diamond and Rajan (1999) that a bank is such a device. When the initial financier is structured as a bank -- financed by demand deposits with a sequential service constraint where depositors get their money back in the order in which they approach the bank until the bank runs out of money or assets to sell -- the banker can commit to pass through the entire amount that that he expects to collect using his specific abilities, to depositors. The reason the bank does not extract rents, thereby making the financial assets it holds, and the claims against them, illiquid, is because it has a fragile capital

structure. The sequential service constraint, where depositors must be fully repaid in the sequence that they appear to withdraw from the bank, creates a collective action problem among depositors. It makes them prone to run on the bank whenever they think their claim is in danger. This enables the banker to commit. When the bank has the right quantity of deposits outstanding, any attempt by the banker to extort a rent by threatening to withdraw her specific abilities will be met by a run, which disintermediates the banker and drives her rents to zero. Thus the banker will not attempt to extort rents and will pass through all collections directly to depositors.

In this way, the bank creates liquidity both for the depositor and the entrepreneur.<sup>2</sup> We do not focus explicitly on an uncertain need for liquidity (as in Diamond-Dybvig [1983]), but it does turn out that demand deposits will provide liquidity to depositors or the relationship lender. When some of the depositors want their money back in the ordinary course of business (in contrast to a run), the bank does not need to liquidate the entrepreneur. It simply borrows from new depositors who, given the strength of their claim, will refinance up till the full value of the amount the bank can extract from the entrepreneur. The bank can thus repay old depositors. In sum, the bank enters into a Faustian bargain, accepting a rigid and fragile capital structure in return for the ability to create liquidity.<sup>3</sup>

In Diamond and Rajan (1999), we examined a world of certainty where rigidity was not a problem, and it is first best to structure the bank as a complete pass through, financed fully with

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<sup>2</sup> The idea that banks provide liquidity on both sides of the balance sheet is also explored in Kashyap, Rajan and Stein (1998). Their argument, which complements ours, is that there is a synergy between lines of credit and demand deposits in that the bank can better use existing sources of liquidity by offering both. They provide empirical evidence consistent with their argument.

<sup>3</sup> Unlike Allen and Gale (1998) who suggest bank runs are optimal from a risk sharing perspective, bank runs in our model have good incentive effects for the banker (as in Calomiris and Kahn (1991)) but could well be harmful ex post. However, we do not model these harmful effects. Our model has some of the features of Diamond and Dybvig (1983) but departs from it in trying to model the illiquidity of the bank's financial assets rather than taking the illiquidity of bank assets as exogenous. Others such as Flannery (1994) also rationalize the coexistence of illiquid loans and demand deposits.

deposits. This maximizes liquidity creation. Once we introduce uncertainty that is observable but not verifiable and thus cannot be used in contracting, we introduce the other side of the trade-off. The rigid capital structure could lead to runs when real asset values fall. The banker now has to trade-off liquidity creation against the cost of bank runs. It may be optimal for the bank to partially finance itself with a softer claim like capital, which has the right to liquidate, but does not have a first-come-first-served right to cash flows. Capital (or its fiduciary representatives), unlike depositors, cannot commit not to renegotiate. While this allows the banker to extract some rents, thus reducing his ability to create liquidity, it also buffers the bank better against shocks to asset values. That bank capital is a buffer against the costs of bank distress is, to some extent, well known. More novel is the cost; the reduced liquidity or credit creation.

A simple example may help fix ideas. Consider an entrepreneur with a project yielding substantial cash flows next period (say 2 in every state). Assume that an experienced relationship lender can liquidate the project's assets for 1.4 in the high state next period and only 0.8 in the low state next period. Both states are equally likely. Finally, assume the discount rate is zero in this risk neutral world, and outside inexperienced lenders cannot obtain anything from liquidating the project, regardless of state.

If any outsider could run the project as well as the entrepreneur, the liquidation value of the project next period would be 2. Now consider a contract that transfers ownership to the financier if the entrepreneur defaults next period. In the event the entrepreneur defaults, the financier would be able to realize 2 by seizing the project and employing one of the reserve army of outsiders to run the project. Hence she would be willing to lend 2 up front. The project would not be illiquid.

The project, however, requires the entrepreneur's specific skills, which is why its value, even when the experienced relationship lender can liquidate (i.e., pick the best outsider to run it), is

either 1.4 or 0.8 depending on state. If the entrepreneur threatens not to repay, the relationship lender can extract repayment only by liquidating assets. Assuming the entrepreneur can make take-it-or-leave-it offers, the relationship lender can extract expected payments up to  $0.5 \cdot 1.4 + 0.5 \cdot 0.8 = 1.1$  which is less than the \$2 the entrepreneur generates. The project is illiquid because it requires the entrepreneur's specific abilities.

Even though the relationship lender can extract payments worth 1.1 from the entrepreneur next period, he cannot raise this much by issuing capital (i.e., non demandable claims) today. This is because the relationship lender's specific skills are needed to extract repayment from the entrepreneur. Without the relationship lender, outsiders (holders of capital) cannot extract anything from the entrepreneur since their value from liquidating the project, and hence their threat point, is zero. So by threatening to quit next period, the relationship lender can, and will, appropriate a rent for his specific skills. Assuming that he extracts half the additional amount he recovers from the entrepreneur, the relationship lender will keep a rent of 0.55 and only pass on 0.55 to outside financiers. Thus the loan to the entrepreneur is also illiquid in that the relationship lender can only borrow a fraction of the cash flows he hopes to generate from it.

Now let the relationship lender (henceforth the banker) finance partly by issuing demand deposits. If the banker attempts to renegotiate these next period, he will trigger off a run which is costly to the banker (we will derive all this). The banker will always pay deposits if feasible, so the only downside of financing via deposits is that there will be a run with attendant costs if the banker cannot pay. Assume half the amount that can be extracted from the entrepreneur is lost if there is a run.<sup>4</sup>

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<sup>4</sup> This could be because the entrepreneur is inefficiently liquidated after a run or because the entrepreneur is confronted by less powerful lenders to whom he pays less.

Now let us see how financing through demandable deposits alters the amount that can be raised today. Suppose the level of deposits is set at 1.4. In the low state, the banker can force the entrepreneur to pay only 0.8, and anticipating this, depositors will run and recover only 0.4. In the high state, the banker will be paid 1.4, which he will pass on to depositors. Thus by setting deposits at 1.4, the banker can commit to paying out  $0.5 \cdot 1.4 + 0.5 \cdot 0.4 = 0.9$ . This exceeds what the banker could raise by issuing only capital -- the banker can raise more with demandable deposits because he does not extract as much in rents.

Of course, there is a cost of issuing too many deposits -- the run in the low state. Can the banker raise more by issuing fewer deposits? Clearly, the cost of the run will be incurred with some probability whenever deposits exceed 0.8. Suppose deposits are set at this level. In the low state next period, the entrepreneur will pay the banker 0.8, which will be passed on to the depositors. In the high state the banker will extract 1.4 from the entrepreneur, pay depositors 0.8, and share the remaining equally with capital. So the banker's expected rent is  $0.5 \cdot 0.5 \cdot [1.4 - 0.8] = 0.15$ , capital gets the same amount, and deposits are safe and are paid 0.8. Thus, the banker can raise 0.95 by issuing a combination of safe deposits and capital. Therefore, by increasing financing through capital and reducing deposits to a safe level, the banker eliminates the costs of distress without increasing the rents he extracts excessively, and such a capital structure enables him to raise the maximum from outsiders.

But there is yet another, and more subtle, effect of capital which we have finessed in the example by looking at a one period problem where the entrepreneur is not liquidity constrained. In the model we will examine shortly, a bank's capital structure influences the amount that the bank can extract from a liquidity constrained entrepreneur, by altering the bank's horizon when it bargains with its borrowers. This effect is reminiscent of Perotti and Spier (1993) who argue that a more levered capital structure enables equity holders to extract more from workers, but the



rationale is quite different. The bank's ability to extract does not change monotonically in its deposit leverage and it depends on the entrepreneur's project characteristics (such as the interim cash flows it generates).

In summary, the optimal capital structure for a bank trades off these three effects of capital -- more capital increases the rent absorbed by the banker, increases the buffer against shocks, and changes the amount that can be extracted from borrowers. The optimal ex ante bank capital structure, as we will argue, depends on the degree of competition in banking, the nature of the available pool of borrowers, and the amount of own capital the banker can bring to the business. We offer some characterizations.

Our model explains why bank capital can be costly, not just in the traditional Myers-Majluf sense of the asymmetric information costs of issuing new capital, but in the more recurring cost of reducing liquidity, and the flow of credit. It can then be used to understand a variety of phenomena. For example, by characterizing the kinds of firms that benefit most from bank finance, it can explain the pattern of disintermediation as a financial system develops. As another example, because financial fragility is essential for banks to create liquidity, our model highlights some of the costs (in terms of lower credit and liquidity creation) of regulatory interventions that attempt to make the banking system safe.

The rest of the paper is as follows. In section I, we lay out the framework and analyze events at date 2 in our two period model. We discuss some empirical implications of the basic trade-off of costs of bank distress versus liquidity creation. In section II, we examine the effects at date 1, and in section III, we consider how capital should be set optimally at date 0.

## **I. Framework**

### **1.1. Agents, Projects, and Endowments.**

Consider an economy with entrepreneurs and investors. The economy lasts for two

periods and three dates -- date 0 to date 2. All agents are risk neutral and the discount rate is zero. Each entrepreneur has a project that lasts for two periods. The project has a maximum scale of 1, but can be funded with an investment  $i$  at date 0 where  $i \in (0,1]$ . It returns a random cash flow with realizations  $C_1^s$  in state  $s$  at date 1 and  $C_2^{s'}$  in state  $s'$  at date 2 per dollar invested if the entrepreneur contributes his human capital. For every dollar invested, the assets created through the initial investment have a random value in best alternative use without the entrepreneur's human capital (also termed "liquidation value"). This has realization  $X_1^s$  immediately after investment until cash flow  $C_1^s$  is due to be produced, and realization  $X_2^{s'}$  from then till  $C_2^{s'}$  is due to be produced. After that, the value of the assets collapse to zero. Funds can also be invested at any date in a storage technology that returns \$1 at the next date for every dollar invested.

Entrepreneurs do not have money to finance their projects. There is a large number of investors, each with \$1/m of endowment at date 0 who can finance entrepreneurs. We assume

$$\text{Min}[E[\tilde{C}_1 + \tilde{C}_2], E[\frac{\tilde{C}_1 + \tilde{C}_2}{\tilde{X}_1} | X_1^s]] > 1 \quad \text{for all realizations of } s \quad (1)$$

so that the entrepreneur's initial project produces greater total cash flow returns viewed from both the date 0 investment and the date 1 opportunity cost of  $X_1^s$  than storage. We will assume, for simplicity, that the project generates sufficient cash flow in the long run, i.e.,  $C_2^{s'} > X_2^{s'}$  so that illiquidity ever prevents an entrepreneur from paying at date 2. We also assume that the aggregate endowment exceeds the number of projects by a sufficient amount so that storage is in use at each date, implying that there is no aggregate shortage of capital or liquidity. As a result, at any date a claim on one unit of consumption at date  $t+1$  sells in the market for one unit at date  $t$ . The exact distribution of endowment is not critical, and one useful alternative assumption about endowments is that there are many new investors at date 1 who invest in storage at the margin.

### 1.2. Relationship-Specific Collection Ability.

As in Diamond and Rajan (1999), the initial lender acquires the specific skills to put assets to their best alternative use and obtains  $X_t^s$  per initial dollar invested, while outsiders or later financiers can generate only  $b X_t^s$  where  $b < 1$ .

Since educating the initial relationship lender takes time and effort, we assume that there can be just one lender for each entrepreneur. We assume that if the loan is seized from, or sold by, the relationship lender, he loses his specific skills at the next date. In other words, the relationship lender needs constant close contact with the borrower to maintain his advantage. While this assumption is not only plausible, it also simplifies the analysis and has no qualitative impact on the results.<sup>5</sup>

### 1.3. Intermediation.

We can motivate the existence of intermediaries by assuming that  $m > 1$ , and more than one investor is required to fully fund the project. If so, investors have no option but to delegate the acquisition of specific collection skills to an intermediary, say a bank. Diamond and Rajan (1999) show that even when  $m=1$  and a single individual can finance the project, so long as the individual has high enough probability of a need for liquidity at an intermediate date, financing through a bank can dominate financing directly from the individual investor. Because loans are illiquid, it can be undesirable to hold them directly (as in Diamond-Dybvig [1983]). However, when the bank can commit to repay new date-1 depositors at date 2, it can issue these deposits to raise money to repay date-0 depositors who come for their money at date 1, thus providing them liquidity. As a

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<sup>5</sup> The assumption certainly affects the outside options of various parties to the bargaining but is important to the results only in that a bank run (see later) serves to discipline the bank even at intermediate dates. It is plausible, if for instance, the bank's specific abilities come from the special information it gets from the relationship (see Rajan (1992), for example). Bank runs would always discipline even if we assumed the other extreme, that the relationship lender never loses his skills. In the intermediate cases, we can show that a bank run at interim dates always disciplines the banker when it is faced by a cash rich borrower, but when the borrower is cash-poor a run will not always be fully disciplinary (i.e., the banker will always be hurt by a run, but may not get zero).

result, we do not explicitly consider the possibility that a fraction of depositors will need liquidity, but such a need is fully consistent with our results because there is no aggregate shortage of liquidity—banks can always raise new funds by offering a competitive rate of return. The reasons for intermediation and the details of the need for liquidity are orthogonal to the issues explored here, so for reasons of space we will not discuss them. The reader should, however, be assured that there is a natural motive for intermediation.

#### **1.4.Contracting.**

We assume that contracts between borrowers and lenders can specify payments and can make the transfer of ownership of the assets contingent on these payments. Furthermore, we assume the existence of accounting systems that can track cash flows once they are produced. However, a borrower can commit to contributing his human capital to a specific venture only in the spot market. Human capital cannot be bought or sold. This implies that borrowers will bargain over the surplus that is created when they contribute their human capital, as in Hart and Moore (1994). Ex ante contracts over payments and ownership will constrain this bargaining.

In order to raise money, a borrower has to give the lender some, possibly contingent, control rights. We consider contracts which specify that the borrower owns the asset and has to make a payment to the lender, failing which the lender will get possession of the asset and the right to dispose of it as he pleases. The realized values of cash and liquidation values are not verifiable or contractible. So a contract specifies repayments  $P_t$  the borrower is required to make at date  $t$ , as well as the assets the lender gets if the borrower defaults. For much of our analysis, allowing the lender to get only a fraction of the proceeds from liquidating the assets even if he is owed more does not add much insight. So in the rest of the analysis, we assume that on liquidation,

the lender gets all the proceeds. Also, for simplicity, partial liquidation is not possible. Finally, the entrepreneur can liquidate himself for as much as the relationship lender.

### **1.5. Bargaining with the Entrepreneur.**

Since the entrepreneur can commit his human capital only in the spot market, he may attempt to renegotiate the terms of the contract (henceforth the loan) that he agreed to in the past. We assume bargaining at date  $k$  takes the following form; the entrepreneur offers an alternative sequence of  $P_t^k$  from the one contracted in the past. He can also commit to making a current payment if his offer is agreed to, as well as commit to contribute his human capital this period. The lender can (1) accept the offer, or (2) reject the offer and liquidate the asset immediately or (3) reject the offer and forego liquidation this period but reserve the right to do so next period (4) reject the offer and sell the assets to a third party. The game gives all the bargaining power to the entrepreneur, apart from the lender's option to liquidate. This is for simplicity only, and modified versions of our results hold when there is more equal bargaining power. If the entrepreneur's offer is accepted, current payments are made, the entrepreneur contributes his human capital, and assumes control of the assets until the next default (if any). The sequence is summarized in figure 1. To fix ideas, let us start with a world of certainty.

**Example 1:** Suppose that it is date 2, and the entrepreneur has promised to pay  $P_2=X_2$ . If the entrepreneur bargains with the initial lender, he knows that the lender can obtain  $X_2$  through liquidation. As a result, he pays  $X_2$  since, by assumption, he generates enough cash flow to do so.

### **1.6. Hold up by an intermediary**

The initial lender in this model is an intermediary who has borrowed from other investors. In the same way as the entrepreneur can negotiate his repayment obligations down by threatening not to contribute his human capital, the intermediary can threaten to not contribute his specific collection skills and thereby capture a rent from investors. The intermediary, by virtue of his

position in the middle, can choose whom to negotiate with first. As in Diamond and Rajan (1999), centrality will be an important source of power for the intermediary. The intermediary will negotiate first with outside investors before concluding any deal with the entrepreneur (else his threat to withhold his collection skills is without bite). So he will open negotiations with investors by offering a different schedule of repayments. The negotiations between an intermediary and investor(s) take much the same form as the negotiations between the entrepreneur and a lender (see Figure 2). The investor can either (1) accept the proposed schedule (2) reject it and bargain directly with the entrepreneur as in figure 1 (this is equivalent to the investor seizing the "asset" -- the loan to the entrepreneur -- from the intermediary), or (3) bargain with the intermediary over who will bargain with the entrepreneur. It is best to see the effect of this potential hold up by the intermediary in our example.

### **Example 1 Continued**

Suppose the intermediary finances his loan to the entrepreneur by borrowing from several investors. Assume for now that there are no problems of collective action among the investors. At date 2, the intermediary can threaten to not collect on the loan to the entrepreneur, and instead leave the investors to collect it. The investors, because of their poorer liquidation skills, can expect to extract only  $\beta X_2$  from the entrepreneur. The intermediary's threat can thus allow him to capture some of the extra amount that only he can collect. If the intermediary and investors split the additional amount extracted evenly, the investors will get  $\frac{1+b}{2} X_2$  and the intermediary will get the remainder, or  $\frac{1-b}{2} X_2$ . Thus, at date 1, the intermediary's inability to commit to employ his specific collection skills at date 2 prevents him from pledging to repay more than a fraction

$\frac{1+b}{2}$  of what he collects from the entrepreneur.

### 1.7. Depositors as Investors.

Thus far we have examined investors who do not suffer from collective action problems. The intermediary cannot raise the full amount he expects to extract from the entrepreneur from these investors because they know he will appropriate a rent for his specialized human capital. If  $X_2$  is not stochastic as of date 1, however, Diamond and Rajan (1999) show that an intermediary can offer demand deposits to investors, and this commits the intermediary to fully collect the loan and pass it through to depositors.

The difference between a generic intermediary financed by ordinary investors (described above) and a bank financed by demand deposits is that the sequential service nature of demand deposits creates a collective action problem that prevents the banker from negotiating depositors down.

To sketch why, we have to first specify the terms of the deposit contract. The deposit contract allows the investor to withdraw at any time. He forms a line with other depositors who decide to withdraw at that time. If the banker does not pay him the full promised nominal repayment  $d_t$ , the depositor has the right to seize bank assets (cash + loans) equal in market value (as determined by what an ordinary investor would pay for the assets -- see above) to the promised repayment  $d_t$ . Depositors get paid or seize assets based on their place in line.<sup>6</sup> Therefore if bank assets are insufficient to pay all depositors, the first one in line gets paid in full while the last one gets nothing.

Suppose the banker announces that he intends to renegotiate and makes an initial offer. Depositors can (1) accept the new terms, or (2) join a line, with positions allocated randomly, to seize the bank's assets of loans and cash based on what is due to them in the original contract--

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<sup>6</sup> An equivalent assumption to depositors seizing loans is that they demand cash and the bank is forced to sell loans at their market value to third parties to meet cash demands. The net effect is the same -- unskilled parties are in possession of the loans after the run.

which we call a *run*, (3) refuse the offer but negotiate without seizing bank assets (see figure 3). All depositors choose between these alternatives simultaneously. At the end of this stage, either the banker or the depositor will be in possession of the loan to the entrepreneur. If depositors have seized the loan, the banker is disintermediated, and the entrepreneur can directly initiate negotiations with depositors by making an offer. The subsequent steps follow the sequence that we have already documented above, and in figure 1.

Thus there is an essential difference between an intermediary bargaining with investors who simply have ordinary debt or equity claims on the intermediary, and the bank bargaining with demand depositors. If the bank attempts to renegotiate, the latter can (and will) choose to run in an attempt to grab a share of the bank's assets and come out whole. As we will argue shortly, the run, by disintermediating the banker, will destroy his rents even though he will continue to have specific skills in the short run. Fearing disintermediation, the bank will not attempt to renegotiate and will pass through the entire amount collected from the entrepreneur to depositors.

### **Example 1 Continued**

How much can the banker commit to pay from the loan with face value  $P_2=X_2$ ? Let the banker issue demand deposits with face value  $d_2=X_2$  in total, raising the money from many depositors.<sup>7</sup> A depositor with claim  $\alpha d_2$  is permitted to take cash, or loans with market value, equal to  $\alpha d_2$  (or to force this amount of loans to be sold to finance the payment of the deposit).

The market value of loans is  $\frac{(1+b)X_2}{2} < X_2$ , so not all the depositors will be paid in full if they

run. If the banker should offer depositors less than  $d_2=X_2$ , then each depositor has the unilateral incentive to run to the bank to get paid in full, whenever other depositors have not done so first.

Therefore, when other depositors have not run on the bank, a given depositor will not make any

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<sup>7</sup> The case where the bank has cash reserves can be easily handled by assuming  $d_1$  is the level of deposits net of cash reserves.



concessions, preferring to run instead. Finally, once a run has fully disintermediated the bank loans, the depositors and the entrepreneur can negotiate about how much will be paid to each depositor. Both the entrepreneur and depositors know that the banker can be hired to collect the full  $X_2$  for a fee of  $\frac{1-b}{2} X_2$ . But since the entrepreneur is now in direct contact with depositors, he can offer to pay  $\frac{1+b}{2} X_2$  directly to the depositors who hold the bank's loans, and the banker will receive zero. Consequently, a bank run drives the banker's rents to zero, and the threat of a run acts as a disciplinary device that allows the banker to commit at date 1 to pay the depositors at date 2 the entire amount  $P_2 = X_2$  extracted from the firm.

Demand deposits thus allow the bank to create liquidity: allow it to borrow more (i.e.,  $X_2$ ) from depositors than the market value of the loan to the entrepreneur (i.e.,  $\frac{1+b}{2} X_2$ ). They work by creating a collective action problem. Depositors are individually better off refusing to enter into a renegotiation with the banker (even though collectively, depositors are weakly better off renegotiating with the bank than seizing assets). Therefore, depositors grab assets first, and negotiate later, but the later negotiations cut out the banker. Despite the possibility of efficient bargaining after a run, the banker is disciplined by a run. Hence the banker does not attempt to renegotiate, and pays out the full amount collected, taking only an infinitesimal rent for his specific skills.

### **1.8. Financing through a mix of deposits and other claims.**

We have seen that investors holding non-deposit claims are negotiated down by the intermediary, while depositors are not. What if both kinds of investors simultaneously hold claims on the intermediary? Let the face value of demand deposits be  $d_2$ . Let other investors -- henceforth called "capital" -- hold a claim on all the residual cash flows (i.e, they hold all the

equity, or a high level of subordinate debt). We show that a rent typically goes to the banker so that the bank is no longer a complete pass-through.

Let the banker threaten not to collect the loan at date 2. We have already argued that he will be unsuccessful in negotiating depositors down. Hence this threat must be directed at capital.

**Example 1 Continued** Without the banker, capital will be able to collect only  $\beta X_2$  from the entrepreneur. If deposits exceed  $\beta X_2$ , capital will not be able to avoid a run if the banker quits, and will get zero. The net amount available to capital and the banker if the bank does employ its skills in collecting the loan is  $X_2 - d_2$ . Since neither can get any of the surplus without the other's co-operation, they split the surplus, and each gets  $\frac{1}{2}(X_2 - d_2)$ . Alternatively, if the face value of deposits is lower than  $\beta X_2$ , capital can get  $\beta X_2 - d_2$  without the banker. The additional surplus generated by the banker with capital's co-operation is then  $X_2 - d_2 - (\beta X_2 - d_2) = (1 - \beta)X_2$ .

Bargaining then gives the banker one half of the additional surplus he generates, or  $\frac{1 - \beta}{2} X_2$ ,

and capital gets the rest of the residual claim on the bank, or  $\frac{1 + \beta}{2} X_2 - d_2$ .

Before proceeding further, we generalize the formal results for date 2.  $d_2$  is the level of deposits going into date 2,  $P_2^1$  is the date 2 repayment promised by the entrepreneur at date 1.

**Lemma 1:**

1) If  $\min[P_2^1, X_2] < d_2$ , depositors will run on the bank and be paid

$$\frac{1}{2} \min[P_2^1, \beta X_2] + \frac{1}{2} \min[P_2^1, X_2].$$

2) If  $\min[P_2^1, X_2] \geq d_2$  and

2.b) if  $\text{Min}[P_2^l, \mathbf{b}X_2] < d_2$  then there is no run, depositors get paid  $d_2$ , the banker gets

$$\frac{1}{2}[\text{Min}[P_2^l, X_2] - d_2] \text{ and capital gets } \frac{1}{2}[\text{Min}[P_2^l, X_2] - d_2].$$

2.c) if  $\text{Min}[P_2^l, \mathbf{b}X_2] > d_2$  then there is no run, depositors get paid  $d_2$  and

2.c.1) if  $P_2^l \leq \mathbf{b}X_2$  the banker gets 0 while capital gets  $P_2^l - d_2$ .

2.c.2) if  $X_2 > P_2^l \geq \mathbf{b}X_2$  the banker gets  $\frac{1}{2}[P_2^l - \mathbf{b}X_2]$  while capital gets

$$\frac{1}{2}[P_2^l + \mathbf{b}X_2] - d_2.$$

2.c.3) if  $P_2^l \geq X_2$  the banker gets  $\frac{1-\mathbf{b}}{2}X_2$  while capital gets  $\frac{1+\mathbf{b}}{2}X_2 - d_2$ .

This lemma highlights the problem of setting deposits too high -- while it will reduce the banker's rents to zero, it will also reduce the amount going to the depositors because it precipitates runs that lead to a loss of the banker's valuable services. But why would the banker set deposits so high as to precipitate a run. For this, we have to introduce uncertainty about date 2 asset values. The ensuing tradeoff is discussed next.

### 1.9. Uncertainty about underlying date-2 asset values.

Let us now assume the underlying value of the entrepreneur's asset is stochastic and takes value  $X_2^H$  with probability  $q_2^H$  and  $X_2^L$  with probability  $1 - q_2^H$  at date 2.<sup>8</sup> The loan has face value  $P_2 = X_2^H > X_2^L$ . Therefore, the bank can collect either  $X_2^H$  or  $X_2^L$ , depending on the

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<sup>8</sup> These probabilities of date 2 values as of date 1 are conditional on the date-1 state,  $s$ , and should be read as  $q_{2s}^H$ , but we suppress this dependency when there is no ambiguity.

stochastic realization of the borrower's business. The market value of the loan at date 1 is

$$\frac{1+b}{2}E[\tilde{X}_2].$$

Without deposits to limit the banker's rents, this is all that the claims on the bank

would be worth at date 1. For the bank to create some liquidity, and to raise more than the market

value of its loan at date 1, it must use some demand deposits. There are two levels of deposits to

consider, low and high:  $d_2 = X_2^L$  and  $d_2 = X_2^H$ .<sup>9</sup> If the low level of deposits is selected, the

banker will capture a rent when  $X_2^H$  is realized (of either  $\frac{1}{2}[X_2^H - X_2^L]$  or  $\frac{1-b}{2}X_2^H$  depending

on whether  $X_2^L > \text{or} < bX_2^H$ ). For now, assume that  $X_2^L < bX_2^H$ . Then the expected total date-

2 payment the banker can commit to make to outsiders, that is to depositors plus other claimants,

when date-2 deposits are low enough to be riskless ( $d_2 = X_2^L$ ), is given by

$$q_2^H \frac{1+b}{2} X_2^H + (1-q_2^H) X_2^L \equiv \bar{P}^{Safe}.$$

Alternatively, to avoid the rent to the banker when the outcome is  $\tilde{X}_2 = X_2^H$ , the bank

could operate with a high level of deposits,  $d_2 = X_2^H$ . However, a bank run would occur if

$\tilde{X}_2 = X_2^L$  is the realization of asset value. Once the run occurs, the sum of the value to

depositors, the banker, and any other claimants on the bank, falls to the market value of the loan,

or  $\frac{1+b}{2} X_2^L$ . So the expected total payment the banker makes to outsiders, that is to depositors

plus other claimants, when deposits are high ( $d_2 = X_2^H$ ) is given by

$$q_2^H X_2^H + (1-q_2^H) \frac{1+b}{2} X_2^L \equiv \bar{P}^{Risky}.$$

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<sup>9</sup> In terms of the amounts that can be raised at date 1, a lower level of deposits than  $d_2 = X_2^L$  is dominated by  $d_2 = X_2^L$  and a level of deposits between  $d_2 = X_2^L$  and  $d_2 = X_2^H$  is dominated by  $d_2 = X_2^H$ . Hence the focus on these two levels.

The most that the bank can commit to pay to outsiders before date 2, is

$\max\{\bar{P}^{Safe}, \bar{P}^{Risky}\}$ . This is less than the total value the banker can collect from the borrower,

$E[\tilde{X}_2]$ , whenever the value of the asset is uncertain. We can also calculate  $\bar{P}^{Safe}, \bar{P}^{Risky}$  when

$X_2^L \geq bX_2^H$ .  $\bar{P}^{Risky}$  is unchanged, and  $\bar{P}^{Safe}$  is given by

$$q_2^H \frac{(X_2^H - X_2^L)}{2} + X_2^L \quad (2)$$

It follows that

**Lemma 2:** (i) If  $q_2^H X_2^H < (1 - q_2^H) X_2^L$  then  $\bar{P}^{Safe}$  is greater than  $\bar{P}^{Risky}$ .

(ii) If  $X_2^L \leq q_2^H X_2^H$ , then  $\bar{P}^{Risky}$  is greater than  $\bar{P}^{Safe}$ .

(iii) If  $X_2^L > q_2^H X_2^H \geq (1 - q_2^H) X_2^L$ , there is a  $\beta^*$  such that  $\bar{P}^{Safe} > \bar{P}^{Risky}$  iff  $b < b^*$ .

Proof: See appendix.

$\bar{P}^{Safe} > \bar{P}^{Risky}$  implies a capital structure with safe deposits raises more external financing than a capital structure with risky deposits. Intuitively, this is the case when the expected loss because of a run outweighs the expected rent that goes to the banker because deposits are not set high enough, i.e., when the costs of financial distress outweigh rent absorption by the bank. Since rent absorption takes place in "high" states while distress takes place in "low" states, this suggests that the bank capital structure that raises the most cash ex ante is one with relatively fewer deposits when bad times are anticipated and more deposits when good times are – the level of deposits should be a leading indicator. Perhaps less obvious is when the intrinsic liquidity of project assets,  $\beta$ , falls, the bank can again raise more by issuing fewer deposits. The intuition here is that the banker's rent in the "high" state is relatively unaffected by the illiquidity of bank assets once they are sufficiently illiquid -- capital has to share half the collections over the value of deposits

with the banker since it cannot pay depositors on its own. However, the cost to investors of a bank run increases with illiquidity. Therefore, the bank raises relatively more when assets become more illiquid by adopting a safer capital structure.

**Corollary 1:**  $\overline{P}^{Risky} - \overline{P}^{Safe}$  increases with a mean preserving spread in the distribution of  $\tilde{X}_2$ .

The risk of the loan repayments is proportional to the risk of the underlying collateral  $\tilde{X}_2$ . So the corollary suggests that the capital structure that raises the most at date 1 contains more deposits as the distribution of loan repayments shift to the tails. The intuition is that as value shifts to the tails, it becomes more important for the bank to commit to pay out the repayments extracted in the high state, while the costs incurred through financial distress in the low state become relatively unimportant.<sup>10</sup> Note that this is observationally equivalent to "risk shifting" behavior (riskier bank loans are correlated with higher leverage), though the direction of causality is reversed, and bank management maximizes the amount raised, not the value of equity.

### 1.10 Implications of the simple one period model.

The model so far could be thought of as a one period model of bank capital structure. If we assume that banks want to set capital structure so as to maximize the amount that they can raise against given loans, our model already has a number of predictions.

#### 1.10.1. The Decline in Bank Capitalization.

Berger et al. (1995) present evidence that bank book capital to assets ratios have been falling steadily in the United States, from about 55% in 1840 to the low teens today. While regulation providing greater implicit government capital to the banks could explain some of the decline, bank capital also declined over periods with little, or no, regulatory change (see Berger et al. (1995), p 402). Our model suggests that as the underlying liquidity of projects,  $\beta$ , increases, the

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<sup>10</sup> Our view that bank capital structure can allow for risky deposits contrasts with the view in Merton and Perold (1993) where capital structure is always maintained such that deposits are completely safe.

capital structure that raises the most finance up front contains more deposits. Thus the increasing liquidity of bank assets as information, the size of market, and the legal environment improve could explain the decline in capital ratios.

### **1.10.2. Cyclical Implications.**

Our model also suggests that deposit ratios should decline as bad times become more likely, and increase in an expected upswing. However, the natural flow of funds into a bank from its loan assets tends to be high in good times and low in bad times. It is relatively easy to buy back non-deposit claims with cash, which the bank has plenty of in good times. But banks may have a hard time adjusting their capital structure in bad times because they will have little cash to pay down deposits. If the amount a bank can raise against a loan is less than the amount that it can get from liquidation, it may be forced to adjust its asset structure by calling those loans and only renewing more liquid loans. This would be exacerbated if, for some un-modeled reason such as asymmetric information, it were hard to issue non-deposit claims at short notice. Thus bank lending would tend to be pro-cyclic, exacerbating any fundamental cyclical components (also see Rajan (1994)). Alternatively, banks may hold down the deposit ratio in good times, but the cost will be that bankers will absorb more rents at such times, and reduce the amount that can be raised.

## **Section II: Date 1**

Thus far, we examined what is effectively a one period model. Two factors simplified our analysis -- the entrepreneur had enough cash to repay what could be extracted, and the date being analyzed was the last date. A similar situation obtains at date 1 if the entrepreneur faces a banker at date 1 with no immediate need for cash. Since neither party has a strong preference over the timing of cash flows, the entrepreneur would offer to pay  $\text{Min}[P_1^0 + P_2^0, \text{Max}[X_1^s, E[\tilde{X}_2|s]]]$  over the two periods, and the offer would be accepted. The additional effects of bank capital structure at date 1 come from it forcing the banker to pay out at date 1. This places an additional

constraint on the banker, giving him a strong preference over the timing of cash flows which, depending on the entrepreneur's cash position, can enhance or reduce the banker's ability to extract payment from the entrepreneur.

## 2.1. Intermediation at date 1.

As before, the entrepreneur either pays or opens negotiations at date 1 by making a take-it-or leave-it offer to the banker. Before concluding these negotiations, the banker then negotiates with capital at the end of which either the banker accepts the entrepreneur's offer, the banker liquidates the entrepreneur, or capital takes over and negotiates with the entrepreneur. The entrepreneur's opening offer is only available for the banker to accept, and if capital takes over, the entrepreneur will open with a new offer.

The easiest way to conceptualize what follows is to assume the banker pays off all financial claimants every period. Because depositors can demand payment at any time, each must get a claim worth as much as can be obtained by demanding payment, while capital is always free to replace the banker, this is without loss of generality. Therefore, the bank's capital structure coming into date 1 determines how much the banker needs to pay out at date 1. But the bank's capital structure leaving date 1 (our focus so far) affects how much it can raise to meet maturing payments. Therefore, the difference between the amount due and amount raised has to be met by extraction from the entrepreneur, else the bank will be liquidated. In addition to the banker's ability to liquidate, the entrepreneur will have to consider this constraint on the banker in making an offer.

We present the most illuminating case, leaving the general proposition for later. From the previous section, we know the maximum the entrepreneur can commit to pay at date 2 is

$E[\tilde{X}_2|s]$ , and the maximum the bank can raise against this at date 1 is  $\max\{\bar{P}^{Safe}(s), \bar{P}^{Risky}(s)\}$ .

Let  $\bar{P}^{Safe}(s) > \bar{P}^{Risky}(s)$  so that the bank can raise the most funds at date 1 by maintaining a safe capital structure at date 2 with deposits low enough to avoid runs. Also let



$$C_1^s + \bar{P}^{Safe}(s) > X_1^s > \bar{P}^{Safe}(s) > \frac{1+b}{2} X_1^s \quad (3)$$

The first inequality implies the cash the entrepreneur can generate together with the amount the bank can raise against the entrepreneur's best date-2 promise are greater than the amount obtained from liquidation at date 1. The second inequality implies that the amount the banker can collect by liquidating at date 1 exceeds the amount the bank can raise. The third implies that the amount the banker can raise exceeds the market value of the date 1 liquidation threat so that holding on to the entrepreneur's loan dominates selling it.

Let us first determine how much the banker has to pay claimants. Let the bank's outstanding deposits coming into date 1 (net of cash reserves if the bank holds cash) be worth  $d_1$ . The banker cannot renegotiate deposits. So at date 1, the banker will only negotiate with existing capital about extracting a rent for his specific skills before he concludes a deal with the entrepreneur. He will first make an offer to capital (as in figure 2). Capital can reject the offer, enter the equal probability take-it-or-leave-it offer game, after which it can still take over the bank if it finds the offer unsatisfactory. Since this is capital's best response, we now determine how much the banker has to offer to avoid takeover.

## 2.2. Negotiations between the banker and capital.

Suppose capital rejects the banker's take-it-or-leave-it offer. This is as if capital takes over the management of the bank after firing the banker, and it gets to negotiate directly with the entrepreneur. If capital liquidates immediately, it can obtain  $\beta X_1^s$ . If capital were to wait until date 2 to liquidate it would get  $bE[\tilde{X}_2|s]$ . Therefore, after rejecting a final offer from the banker, capital expects  $Max[b \max\{X_1^s, E[\tilde{X}_2|s]\} - d_1, 0]$ .

By contrast, if capital makes the take-it-or-leave-it offer, it does not have to give the banker anything for his services (since it has the loan to the entrepreneur, and the banker has no right to collect without the legal authority embedded in the loan). Therefore, it asks the banker to collect from the entrepreneur, and capital gets the ensuing loan repayment net of deposit payments of  $Max[X_1^s - d_1, 0]$ .<sup>11</sup>

Since each party gets to make the take-it-or-leave-it offer with equal probability, capital will expect to get a rent from the banker of

$$p_1^C(s) = \frac{1}{2} Max[\mathbf{b} Max[X_1^s, E(\tilde{X}_2|s)] - d_1, 0] + \frac{1}{2} Max[X_1^s - d_1, 0] \quad (4)$$

On inspection, the total payment,  $p_1^C(s) + d_1$  that has to go to date-1 claimants is (weakly) increasing in the level of deposits. Capital structure coming into date-1 therefore affects the total amount the banker has to pay out at date 1. Now we know how much the entrepreneur can pay, how much the banker can raise against the entrepreneur's payments, and how much the banker has to pay claimants, we can determine how much the entrepreneur actually pays. Let us therefore examine negotiations between the entrepreneur and the banker.

### 2.3. Negotiations between banker and entrepreneur.

Suppose the entrepreneur makes an offer at date 1. The easy case is when the banker's best response is to allow the project to continue, while retaining the right to liquidate at date-2. This is the case when  $X_1^s < E(\tilde{X}_2|s)$ , and  $P^{Safe} \geq p_1^C + d_1$ . The banker can then raise enough money

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<sup>11</sup> Alternatively, capital could ask the banker to do nothing at date 1, and pay everything he can commit to pay out of date-2 collections. We have seen that the banker can commit to pay the capital and deposits withdrawn at date 2 at most  $\bar{P}^{Safe}$ . However, in the current case, immediate liquidation is preferred by capital because  $X_1^s > \bar{P}^{Safe}$  from (3).

against date-2 promised payments to satisfy capital and depositors so capital structure does not constrain the banker. The banker is always patient and has a credible threat to liquidate at the date the yields the largest value. Anticipating this, the entrepreneur will offer payments  $P_1^l=0$  and  $P_2^l = X_2^H(s)$ , and the offer will be accepted.

### 2.3.1. The interesting case: the possibly impatient banker

The more interesting case is either when  $X_1^s \geq E(\tilde{X}_2|s)$ , or the level of deposits coming into date 1 is so high that  $p_{I+d_I}^C > P^{Safe}$ . The banker has to liquidate if the offer is unacceptable. Since  $C_1^s + \bar{P}^{Safe} > X_1^s$  from (3), the cash the entrepreneur generates and the date-2 promises he can make are sufficient to make an acceptable offer.

Since the entrepreneur is indifferent between a dollar paid at date 1 and a dollar paid at date 2, and the banker may prefer earlier payment, we can focus without loss of generality at payment offers such that  $P_2^l > 0$  only if  $P_1^l = C_1$ , i.e., the entrepreneur promises a positive date-2 payment only if he has no more cash to make date-1 payments. Let  $q_{2s}^H$  denote the probability of  $X_2^H$  given the state  $s$  at date 1. For the banker to accept an offer, two conditions must hold.

First, the amount paid by the entrepreneur at date 1 together with any date-1 amounts the bank raises by issuing new claims to be repaid out future recoveries from the entrepreneur have to be enough for the banker to pay the depositors and capital coming into date 1. So if  $Pledgeable(P_2^l)$  is the amount the bank can raise today against a date-2 promise of  $P_2^l$  by the entrepreneur<sup>12</sup>, we

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<sup>12</sup> More specifically, it is  $q_{2s}^H P_2^l + (1 - q_{2s}^H) \min[P_2^l, X_2^L]$  if  $P_2^l \leq bX_2^H$  and the capital structure can be set so that the bank does not collect a rent. It is  $q_{2s}^H \frac{(1+b)}{2} P_2^l + (1 - q_{2s}^H) X_2^L$  if  $P_2^l > bX_2^H$  and the bank does collect a rent at date 2. If  $P_2^l > X_2^L > bX_2^H$ , the expression is  $q_{2s}^H \frac{(P_2^l - X_2^L)}{2} + (1 - q_{2s}^H) X_2^L$

have

$$P_1^l + Pledgeable(P_2^l) \geq p_1^c + d_1 \quad (5)$$

Second, the banker should get more over the two dates after paying out all claimants than if he liquidates. Since the required payment to claimants does not depend on whether he liquidates or not, this implies

$$P_1^l + q_{2s}^H P_2^l + (1 - q_{2s}^H) \text{Min}[P_2^l, X_2^L] \geq X_1^s \quad (6)$$

We will now show that, depending on how much cash the entrepreneur has, and the level of deposits coming into date 1, the entrepreneur's total payments to the bank may exceed  $\text{Max}[X_1^s, E(X_2|s)]$  even though the date 1 liquidation threat is what enables the banker to extract repayment. It may be useful to first outline the intuition with the numerical example.

### 2.3.2. Numerical example.

Let  $\beta=0$ ,  $X_1^s=0.99$ ,  $X_2^L=0.8$ ,  $X_2^H=1.4$ , and  $q_{2s}^H=0.5$ . As calculated in the introduction,  $\bar{P}^{Safe}$  is given by (2), and equals 0.95,  $\bar{P}^{Risky} = 0.9$ .

First let deposits coming into date 1,  $d_1$ , be 0. Then the total payments the bank has to make at date 1 =  $p_1^c + d_1 = p_1^c = 0.77$  (substituting values in (4)). Since  $E[\tilde{X}_2|s] = 1.1 > X_1^s = 0.99$ , the banker will extract an expected amount of 1.1 at date-2 from the entrepreneur if it turns down the entrepreneur's offer. The bank can raise  $\bar{P}^{Safe} = 0.95$  at date 1 against the expected date-2 collection from the entrepreneur. Since it has to raise only 0.77 to pay off date-1 claimants, it can do so even by rejecting the entrepreneur's offer. Moreover, the

difference between the expected inflow of 1.1. and the outflow of 0.77 (to pay off those who put in money at date 1) will be a rent to the banker.

As the level of deposits is increased from 0 to 0.7, an increase in deposits is met by a commensurate reduction in the rents to capital, and total payout to investors remains constant. But when  $d_1$  exceeds 0.7, total payout to investors increases and if  $d_1 > 0.91$ , the total payout to date-1 claimants exceeds  $\bar{P}^{Safe} = 0.95$ . Since this is the maximum the bank can raise at date 1, its horizons shorten and it will liquidate at date 1 if not paid enough by the entrepreneur. Consider deposits set at  $d_1 = 0.99$  so that from (4),  $p_{1(s)}^C + d_1 = 0.99$ .

Now let us vary the cash the entrepreneur has to see how much he pays. An entrepreneur with low cash,  $C_1^s < 0.04$ , will always be liquidated if he attempts to renegotiate his loan. This is because the most the entrepreneur can offer without being liquidated is  $C_1^s + \bar{P}^{Safe} < 0.99$ , and the bank needs 0.99 to avoid a run by depositors. But at  $C_1^s = 0.04$ , the entrepreneur can offer an immediate payment of  $P_1^1 = C_1^s = 0.04$ , and a future payment  $P_2^1 = 1.4$ . This will be accepted since the banker gets  $C_1^s + \bar{P}^{Safe} = 0.99$  to pay off maturing date-1 deposits. The total amount the banker will collect from the entrepreneur over date 1 and date 2 is  $C_1^s + E[\tilde{X}_2 | s] = 0.04 + 1.1 = 1.14$  which exceeds  $Max[X_1^s, E(X_2 | s)] = 1.1$ , the amount the banker could collect if we ignored the effect of the bank's capital structure.

Intuitively, the banker's need to pay claimants at date 1 shortens his horizons and makes his date-1 liquidation threat credible even though it is inferior to the date-2 liquidation threat. In order to avoid liquidation by the banker, the entrepreneur has to help the bank pay its depositors. But the entrepreneur can pay only 0.04, and the rest has to be raised by the bank against future promises by the entrepreneur. Since only a fraction of the future payments by the entrepreneur

translate into current cash raised by the bank (the entrepreneur pays 1.1 while the bank raises only 0.95 against it) the entrepreneur ends up overpaying to avoid liquidation. Of the total 1.14 in expected payments the entrepreneur makes, 0.99 will be paid to outside investors, and the banker will keep the rest as rent.

As the entrepreneur's date-1 cash inflows increase, he can make more of his payments in cash and less in inefficient date-2 promises that involve paying an additional rent to the bank. Eventually, the required date-2 promise falls to such a level that it no longer requires the bank's special skills to collect (the loan to the entrepreneur becomes liquid), and the bank's rent falls to zero. Therefore, the total payment made by the entrepreneur falls as he generates more cash, and when  $C_1^s \geq 0.24$ , his payment bottoms out at 0.99. Note that the entrepreneur now pays less than  $Max[X_1^s, E(X_2|s)] = 1.1$ , and the banker's short horizon hurts his ability to collect.

### 2.3.3. More Formally.

Let us now determine the entrepreneur's actual payments more formally and show why he overpays. As (5) indicates, if deposits due at date 1 are high so that the bank has to pay out a lot at date 1, while the entrepreneur generates little cash at date 1 so that  $P_1^l$  is small, he may have to promise to pay  $P_2^l > bX_2^H$  at date 2 for the bank to raise enough to pay off date-1 claimants. But such a high promised payment can only be collected by the banker which implies that the banker will get a date 2 rent of  $\frac{q_{2s}^H}{2} [P_2^l - bX_2^H]$ . So an entrepreneur with little date-1 cash has to use an inefficient means of payment -- date-2 promises which have an element of leakage in that some of it goes as a rent to the bank.

We cannot immediately conclude that the date-2 rent going to the bank is entirely excess payment. The bank extracts payments by threatening to liquidate at date 1 for  $X_1$ . If the amount owed to date-1 claimants is less than  $X_1$  so that the banker gets some rents at date 1, the entrepreneur could offset the rent the bank collects at date 2 by paying less at date 1. But if the bank pays out everything it gets at date 1 to claimants, the rent at date 2 cannot be offset and becomes entirely excess payment by the entrepreneur.

In particular, the total amount the entrepreneur pays is

$$X_1^s + \text{Max} \left\{ \left[ \frac{q_{2s}^H}{2} (P_2^1 - bX_2^H) - (X_1^s - d_1 - p_1^C) \right], 0 \right\} \quad (7)$$

which is the sum of his liquidation threat and the net uncompensated rent he has to pay the bank (the term in square brackets in (7)). The higher the level of deposits, the lower is the date-1 rent going to the bank,  $(X_1^s - d_1 - p_1^C)$ , the less there is to offset the high date-2 rent with, and the more the total payment by the entrepreneur. The most that can be paid by the entrepreneur is when  $d_1 = X_1^s$  so that the bank's date-1 rent is zero, and all the rent paid at date 2 is excess payment. As (7) suggests, the total payment by the entrepreneur is then a function of  $P_2^1$ . When the entrepreneur has to pledge the maximum date-2 amount possible for the bank to avoid liquidation,  $P_2^1 = X_2^H$ . Therefore, with such a cash-poor entrepreneur, the bank can extract up to  $X_1 + q_{2s}^H \frac{(1-b)}{2} X_2^H$  which, using the second inequality in (3) is greater than  $E[\tilde{X}_2 | s]$ .

Of course, a deposit intensive date-1 capital structure that shortens the bank's horizons can also hurt its ability to extract repayment if the entrepreneur's project generates a lot of cash at date 1. To see this, if the entrepreneur generates enough cash at date 1 so that  $P_2^1 \leq \beta X_2^H$ , the

total payment given by (7) is only  $X_1^s$ . If  $E(\tilde{X}_2|s) > X_1^s$ , the entrepreneur will pay less to the bank than a patient bank can extract, and the shortening of horizon makes the bank “weak”. Thus the amount that can be extracted from the entrepreneur depends in a non-monotonic on the bank's leverage and the entrepreneur's liquidity.

#### **2.3.4. Related Literature.**

While others (Berglof and Von Thadden (1994), Bolton and Scharfstein (1996), and Dewatripont and Tirole (1994)) have analyzed the role of multiple creditors in “toughening” up a borrower’s capital structure, we do not know of any other work that examines the effect of a tough capital structure on an intermediary’s behavior towards borrowers. The closest work to ours is Perotti and Spier (1993) who examine the role of senior debt claims on management’s ability to extract concessions from unions. In their model, management can credibly threaten to under-invest by taking on senior debt. Of course, this is simply a ploy to extract concessions from unions. In our model, a deposit intensive capital structure allows the bank to credibly threaten to liquidate. However, if the bank gains it is not because the borrower makes concessions, but because he is forced to make overly expensive future promises to avoid liquidation.

#### **2.4. General Characterization of Date 1**

Thus far, we have only examined a special case, albeit one that contains the most interesting implications. More generally,

##### **Proposition 1**

If the entrepreneur has to renegotiate his payment at date 1, the outcomes are as follows.



1) If  $d_1 > \text{Max}\{\bar{P}^{\text{Safe}}, \bar{P}^{\text{Risky}}, X_1^s\}$ , the entrepreneur offers nothing at date 1 and there is a bank run. The run reduces the amount collected by depositors to  $\text{Max}\{\frac{1+b}{2} X_1^s, bE[\tilde{X}_2|s]\}$ , and drives the payoff of capital and the banker to zero. In the rest of the proposition, the level of  $d_1$  is assumed less than or equal to  $\text{Max}\{\bar{P}^{\text{Safe}}, \bar{P}^{\text{Risky}}, X_1^s\}$ .

2) If  $\text{Max}\{\bar{P}^{\text{Safe}}, \bar{P}^{\text{Risky}}\} \geq X_1^s$  then the bank cannot use its date-1 liquidation threat. If  $\bar{P}^{\text{Risky}} > \bar{P}^{\text{Safe}}$ , there is a level of date-1 net deposits beyond which the amount collected from the entrepreneur falls from  $E[\tilde{X}_2|s]$  to  $\bar{P}^{\text{Risky}}$ . If  $\bar{P}^{\text{Risky}} \leq \bar{P}^{\text{Safe}}$  the level of date-1 net deposits has no effect on total collections which are always  $E[\tilde{X}_2|s]$ .

3 a) If  $\bar{P}^{\text{Risky}} < \bar{P}^{\text{Safe}} < X_1^s$ , there is a  $d^*$  such that for every  $d_1 > d^*$ , we can find a  $C_1^{\text{Liq}}(d_1)$  such that the entrepreneur will be liquidated with some probability if he defaults at date 1 when  $C_1^s < C_1^{\text{Liq}}$ . 3 b) If further,  $X_1^s > E[\tilde{X}_2|s]$ , there is a  $d^{**}$  such that for every  $d_1 > d^{**}$ , there is a range  $[C_1^*, C_1^{**})$  such that the bank extracts more than  $X_1^s$  from the entrepreneur if  $C_1^s \in [C_1^*, C_1^{**})$ . For any given  $d_1 > d^{**}$ , the amount extracted by the bank increases until  $C_1^s$  equals  $C_1^*$  and then decreases monotonically as  $C_1^s$  increases.

3 c) If  $E[\tilde{X}_2|s] > X_1^s$ , there is a  $d^{***}$  such that for every  $d_1 > d^{***}$ , there is a range  $[C_1', C_1'')$  such that the bank extracts more than  $E[\tilde{X}_2|s]$  from the entrepreneur iff  $C_1^s \in [C_1', C_1'')$ . There is a  $\bar{C}_1$  such that the bank extracts only  $X_1^s$  iff  $C_1^s \geq \bar{C}_1$ . For any given  $d_1 > d^{***}$ , the amount extracted by the bank increases until  $C_1^s$  equals  $C_1'$  and then decreases monotonically as  $C_1^s$  increases.

4) If  $\bar{P}^{Risky} < \bar{P}^{Safe} < X_1^s$ , then capital structure has no effect on the expected amount the bank extracts if  $E[\tilde{X}_2|s] \leq X_1^s$ . When  $E[\tilde{X}_2|s] > X_1^s$ , there is a  $d$  such that the bank extracts less than  $E[\tilde{X}_2|s]$  iff  $d_1 \geq d$ .

Proof: See Appendix.

We have seen that at date 2, a higher level of deposits in the capital structure has two effects. It increases the chances of a bank run, and it decreases the rent absorbed by the banker. The proposition suggests there is an additional effect of capital structure at date 1; it changes the amount that can be extracted from the entrepreneur. The most general rationale is that a deposit intensive capital structure gives the bank a need for cash. This can hurt the bank's ability to extract if the entrepreneur has lots of cash since he can take advantage of the bank's need for liquidity to drive down payments. By contrast, if the entrepreneur has little cash, he has to make excessive future payments because the bank can credibly discount future promised payments at a high rate -- the rate which the bank's investors will demand given the project's illiquidity to put up money to help the bank survive today. Thus borrowers may have to make greater expected payments than if they were faced by a less constrained lender.

### **Section III: Date 0**

Proposition 1 is perhaps the most important result in the paper. It indicates the effects of a pre-existing capital structure on the payments that will be made by an entrepreneur, and on the bank's health. The banker's choice of capital structure at date 0 is then simply a matter of aggregating the effects across multiple states, and choosing an optimal capital structure given that he wants to maximize the amount of surplus he captures over the two periods. Clearly, the optimal structure depends on the competitive environment, the available projects, and the amount of funds he starts

out with. Space considerations restrict us to examining only the case of perfect competition in the banking sector where all projects for which the banker can raise sufficient capital by pledging payments to outside depositors and capital are funded.<sup>13</sup> As shown in the previous section, higher deposits can increase the amount collected by the bank but some of it stays as a rent in the bank. Therefore, unless the bank has its own funds up front to pay for the ex post rents it will extract, it cannot lend more as a result of its higher collections. This suggests two sub cases -- the first when the banker starts with no money of his own and the second when he has an initial endowment of inside capital.

### 3.1. Date-0 Trade-offs when banking is competitive and banker has no funds of his own.

When the banker has no funds of his own at date 0, the level of deposits going into date 1 will be set such that it minimizes the rent that flows to the banker, provided the project can be fully funded. Let there be two states of nature at date 1, H and L, where  $s$  denotes the state of nature. The maximum that can be pledged to outsiders at date 1 for a particular state indicates the level of claims that can be refinanced. This maximum is given by  $\bar{P}_1(s) \equiv \max\{X_1^s, \bar{P}^{Risky}(s), \bar{P}^{Safe}(s)\}$ , where  $\bar{P}^{Risky}$  and  $\bar{P}^{Safe}$  are the maximum date-2 pledgeable cash flows with date 2 state probabilities that are conditional on state  $s$  at date 1. Without loss of generality, let the amount pledgeable at date 1 in state H exceed the amount pledgeable in state L. The bank can finance with safe deposits at date 0 if  $d_1 \leq \bar{P}_1(L)$ . This implies a date 1 rent to the banker when state H occurs. The total amount that can be raised through deposits and capital at date 0 is then

$$\bar{P}_0^{Safe} = \bar{P}_1(L) + q_1^H \left\langle \frac{1}{2} [\max[\mathbf{b} \max\{X_1^H, E[\tilde{X}_2|H]\} - \bar{P}_1(L), 0] + \frac{1}{2} [\bar{P}_1(H) - \bar{P}_1(L)] \right\rangle.$$

where the second term is the rent that accrues to capital at date 1 in state H.

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<sup>13</sup> For a paper that obtains the pricing and quantities of bank capital in an equilibrium setting, see Gorton and Winton (1995).

If deposits  $d_1$  exceed  $\bar{P}_1(L)$ , there will be a run at date 1 in state L. This reduces the pledgeable payment to outsiders in that state to  $\max\{\frac{1+b}{2} X_1^L, bE[\tilde{X}_2|L]\}$ . The maximum that can be raised at date 0, given a run in the low state at date 1, is then obtained by setting  $d_1 = \bar{P}_1(H)$ . The date-0 amount raised is

$$\bar{P}_0^{Risky} \equiv q_1^H \bar{P}_1(H) + (1 - q_1^H) \max\{\frac{1+b}{2} X_1^L, bE[\tilde{X}_2|L]\}.$$

It is now easy to see the date-0 capital structure under competition. If \$1 has to be raised and  $\bar{P}_0^{Risky} \geq 1 > \bar{P}_1(L)$ , and  $\bar{P}_1^{Risky}(H) \geq \bar{P}_1^{Safe}(H)$ , so no rents need be given to the banker, the firm is best off borrowing from a risky bank. Of course, this result would be tempered if the firm suffered some (unmodeled) costs when the bank was in financial distress. By contrast, if  $\bar{P}_0^{Safe} \geq 1 > \bar{P}_0^{Risky}$ , the project cannot be financed with risky deposits. The bank will choose to raise a level of deposits at date 0 that will be safe in all states at date 1. It will issue capital to fund the rest of the project. So even under competition, rents will accrue to the banker, simply because he is liquidity constrained (in the sense of having no inside capital) and cannot pay for the rents up front.

### 3.2. Date-0 Trade-offs when banker has funds of his own.

Now let the banker have the endowment to pay up-front for the rents he extracts. The level of deposits going into date 1 is determined by trading off the total amount collected from the entrepreneur (which varies with the level of deposits as seen in the previous section) against the risk of runs (which increases with deposits). A highly levered bank may now have a comparative advantage in funding an entrepreneur who expects to generate only modest amounts of cash at interim dates --the bank can extract more from such an entrepreneur and thus can lend more money up front. By contrast, as proposition 1 suggests, if  $E(\tilde{X}_2|s) > X_1^s$ , an entrepreneur with

high anticipated date-1 cash inflows may prefer a well-capitalized bank since such a bank can wait to liquidate, and will collect  $E(X_2|s)$ . Thus our theory predicts a matching between banks and entrepreneurs for which there is some empirical evidence (see Hubbard, et al. (1998)).

#### **IV. Robustness**

Let us now examine how robust our model is to changes in assumptions.

##### **4.1. Actions other than threats to quit.**

Because the financial asset requires the banker's collection skills, the threat of dismissal is not always a credible sanction. However, a run serves to discipline and thus helps control many actions that can be observed by outsiders. The discipline occurs because depositors, anticipating losses, run and disintermediate the banker, driving his rents to zero.

Actions that can be controlled by the threat of disintermediation include the bank operating inefficiently, making poor credit decisions, incurring excessive labor costs, or even substituting assets. Some of these actions entail losses to depositors (and benefits to the banker) that are not imposed instantaneously. In such cases, or in cases where a banker's threats cannot be responded to immediately, some short-term debt could mature before the threat is carried out or responded to. Such short-term debt could have properties similar to demand deposits, and this is what we now examine.<sup>14</sup>

##### **4.2. Can the intermediary do without demandable debt?**

Demand deposits have three important characteristics. First, depositors can ask for repayment at any time. Second, they have priority over any other claim if they ask for repayment. Third, if there are multiple depositors, each one can establish priority with respect to the other only

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<sup>14</sup> We assume the information possessed by depositors is obtained freely and depositors do not spend money to monitor the bank. A generalization of our approach is to consider either low cost monitoring of information about banker actions, or situations where a subset of depositors learn banker actions and incipient runs reveal information to other depositors. This would allow us to incorporate the insights of Calomiris-Kahn [1991], where the fact that the first few depositors get paid in full provides incentives for the

by seizing cash and forcing disintermediation. An important question is to what extent a financial intermediary can create liquidity as easily by financing with short-term debt. What properties of demand deposits are necessary for our result?

It turns out that it is hard for the intermediary to reproduce the effects of demand deposits without issuing something that looks very much like a deposit. To see why, suppose the bank finances at date 1 by issuing a single class of short-term debt maturing in one period. If, at date 2, the banker attempts to renegotiate payments, the short-term creditors will have no option but to give in; because they are treated identically, they are better off accepting the banker's terms. The important difference between short-term debt and demand deposits here is not maturity, but that all creditors in the same class of short-term debt enjoy the same seniority, so there is no collective action problem to force disintermediation and discipline on the bank. It is thus important that some creditors should be able to achieve priority only by demanding payment. This then leads to disintermediation.

Of course, by allowing all the action to take place only at date 1 or date 2, we are obscuring differences in maturity that exist between demand deposits and short term debt. This could lead to additional differences in the ability to control bank rents. For instance, suppose that the banker's demand for rents has to be responded to before any debt matures. Then the holders of the various classes and maturities of debt who would be impaired by the banker's threat if it were carried out, will make concessions. Importantly, the unimpaired classes will not impose any discipline on the banker. Even if some of this debt matures before the banker's threat can be carried out, they will not demand payment on maturity if granted sufficient future priority to keep them unimpaired.

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monitoring of malfeasance, and of Park [1999] where potentially impaired senior creditors have the strongest incentive to monitor a borrower.

If, however, the banker cannot maintain maturing debt's effective priority over other classes of debt going forward, then maturing short-term debt can have features similar to demand deposits. If the banker cannot offer maturing creditors a future claim equal in worth to what they can get immediately, they will demand immediate payment. The amount of disintermediation that will occur is then equal to the amount of demand deposits plus the amount of debt maturing before the banker's threat can be responded to by creditors. The banker's rents will be restricted to a function of the extra value that he can collect on the assets that remain in the bank.

Finally, we have ignored throughout the paper any rationale for investors themselves to want demandable claims. If, as in Diamond and Rajan (1999), investors have random liquidity needs, then demandable deposits would be preferable to short maturity debt even if they have similar disciplinary effects.

#### **4.3. Multiple Borrowers.**

We have analyzed outcomes with only one borrower. Does the bank's ability to extract more than  $\text{Max}[X_1^s, E(X_2|s)]$  change if it had multiple borrowers? The qualitative answer is no. Whether assets are contained in one borrower or multiple borrowers, the bank has the right to liquidate if the borrower defaults. Of course, since the debt capacity of each borrower is the maximum of his project's date-1 and date-2 liquidation values, the sum of individual debt capacities will be more than the maximum of aggregate date-1 and date-2 liquidation values.<sup>15</sup> Nevertheless, the principles we have examined will apply.

For example, the use of the date-2 liquidation threat may dominate for some borrowers. However, if the bank has issued sufficient demand deposits, it may have to threaten to liquidate some of these borrowers at date 1 itself. There is qualitatively nothing new if it has to threaten to liquidate all borrowers to meet the needs of claimants. There will be no strategic interaction

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<sup>15</sup> By Jensen's inequality, the sum of maximums is greater than the maximum of the sums.

between borrowers – each of them will have to pay up in order to avoid liquidation. If, however, the bank does not need to threaten all borrowers with date-1 liquidation because its capital structure allows it some slack, the bank may have to discriminate between borrowers. Assuming that at each date, it can choose the sequence in which it negotiates with borrowers, our analysis indicates the bank should negotiate first with the cash rich while it still has the leeway to meet its pressing needs from later borrowers. This allows it to use the date-2 liquidation threat with the cash rich – somewhat paradoxically, it will not press the cash rich for immediate payment. As it concludes these deals and its leeway to accept future payments falls, it should negotiate with the cash poor who will have to make expensive future promises to avoid immediate liquidation – the cash poor will be leaned on heavily. Thus apart from possibly variations in the behavior of a highly levered bank towards heterogeneous borrowers, there is nothing qualitatively different in the analysis of multiple borrowers.

#### **4.4. Could the entrepreneur issue deposits?**

One could also ask why the entrepreneur does not reduce his cost of capital by directly issuing demand deposits. It turns out that since the entrepreneur's human capital is still essential *ex post* to the generation of cash flows, he cannot commit to lower rents by issuing demand deposits. Intuitively, depositors in the firm will seize the firm's assets after a run. But since the entrepreneur is still the best user of the assets, they will rehire the entrepreneur after they take the assets, and thus will be forced to pay him his rents. Unlike the banker, the entrepreneur is not redundant *ex post*, and hence demand deposits that induce depositors to grab assets do not discipline him. As a result, demand deposits will be much less effective in the capital structure of industrial firms, and firm capital structure will tend towards irrelevance.

#### **4.5. Cash and Collateral.**

Thus far, we have not examined what happens if either the entrepreneur or the bank store



cash. If cash is simply treated as an asset with  $\beta=1$ , it turns out that the storage of cash has no effect on our results. For example, at date 1 only net debt,  $P_1 - c_b$  or  $d_1 - c_b$  matter, where  $c_f$  is cash stored by the firm at date 0 and  $c_b$  is cash stored by the bank. So everything that is achieved by holding cash is achieved by taking on less debt.

Stored cash does have use if it cannot be seized by the lender but can be used at the borrower's discretion. Essentially, as in Hart and Moore (1998), it is one way to make simple contracts more contingent. To see this, let  $C_1^L + E[\tilde{X}_2|L] < X_1^L$  so that the bank will liquidate in the low date-1 state if the entrepreneur defaults. In order to avoid liquidation in the low state, the entrepreneur must not be required to pay more than  $P_1 \leq C_1^L$ . But this will limit what he can pay in the high state to  $C_1^L + E[\tilde{X}_2|H]$ . If the date 1 liquidation threat in the high state allows the bank to collect more than this (i.e.,  $X_1^H > C_1^L + E[\tilde{X}_2|H]$ ) then liquidation in the low state may be averted only at the cost of drastically reducing the total amount the entrepreneur can commit to pay.

Stored cash that the entrepreneur has complete discretion over can help in this situation.<sup>16</sup> The bank could lend the entrepreneur  $1+x$  at date 0, set  $P_1 = \infty$ , and have him hold cash of  $c_f=x$ .

In the low state at date 1, the entrepreneur can avoid liquidation by pledging

$x + C_1^L + E[\tilde{X}_2|L] = X_1^L$ . In the high state, the entrepreneur will pay  $X_1^H$ . So the collateral value in the high state at date 1 can be fully utilized without incurring excessive liquidation.

It turns out that the role cash plays is identical to that played by a clause giving the borrower an inviolable claim to a fixed quantity of the assets on liquidation. When  $C_1$  is low, the bank can be deterred from liquidation even if the entrepreneur defaults by reducing the amount the

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<sup>16</sup> In other words, the cash is held in such a form that it is not available to the bank when the bank liquidates -- either because the borrower has transformed it (see Myers and Rajan (1998)) or because the borrower has stored it in a form only he can access.

bank can keep of liquidation proceeds. If the first  $x$  units of liquidation proceeds go elsewhere, for example to the entrepreneur, then the bank will only liquidate after a default if  $C_1$  plus what the borrower can pledge at date 2 is less than  $X_1^s - x$ . By setting  $x = X_1^L - C_1^L - E[\tilde{X}_2|L]$ , liquidation is avoided after a default in state L. In state H, the bank can then collect up to  $X_1^H - x$  which may be substantially more than  $C_1^L + E[\tilde{X}_2|H]$ .

In practice, it may be hard to give the entrepreneur an inalienable part of the underlying project, especially when the project is not divisible. In addition, even if this were easy, there could be times when the liquidation values are too high, and this will give the entrepreneur incentives to store cash to blunt the lender's liquidation ability. Our model predicts entrepreneurs will hold extra cash to keep control either when a cash shortage could lead to liquidation or when a cash shortage could increase the amount that the lender can extract. These roles for cash can be part of the original implicit deal, and anticipated by the bank.<sup>17</sup>

#### 4.6. Uncertainty and incomplete contracts

State contingent deposit contracts would allow the promised payment to depositors to fluctuate with the state and thus allow the bank to pay out everything to depositors. We have assumed that the uncertainty is non-contractible so that the bank cannot write such contracts.<sup>18</sup> Alternatively, if the state were contractible, the bank could purchase insurance against poor borrower repayment outcomes, rather than using capital as an indirect hedge against uncertainty. We do not explicitly model the constraints that prevent contingent contracting. Previous work has

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<sup>17</sup> This suggests a role for cash balances different from the traditional one. Instead of giving the bank greater comfort or collateral, fungible cash balances that can be drawn down at the discretion of the entrepreneur offer him a way to limit the bank's power in a way that enhances overall efficiency.

<sup>18</sup> While deposits cannot be contingent on the state, we do allow loans seized from the bank to be sold at a market price that is state contingent. More plausibly, the bank sells loans, and realizes cash to repay depositors. If loans are heterogenous, and the bank can choose what to sell, it may be hard to infer from a few loan sales what the state is. But many loans are sold only if the bank is largely disintermediated. Therefore loan sale prices will reflect the state only if the bank is run. In general, therefore, loan sale prices cannot be used to make normal deposit payments contingent on the state, even if sale prices were verifiable.

motivated these limits in settings very similar to ours by private information (Townsend [1979], Diamond [1984]), unobservable renegotiation possibilities (Hart-Moore [1999]), coalition formation (Bond [1999]) or collateral constraints (Holmstrom-Tirole [1998], Krishnamurthy [1999]). We intend in future work to examine the relative roles of capital and risk management in settings where some limited contingent contracts would be feasible.

Our model has some common features with that in Diamond [1984]. The value lost from disintermediation in our model has a role somewhat similar to the distress costs (non-pecuniary penalties) in Diamond [1984] that help to resolve ex-post information asymmetry. In both models, a borrower's uncertain ability to repay leads useful commitment devices to be ex-post costly for some realizations. In Diamond [1984], it is shown that deposit contracts should be contingent on observable aggregate shocks (or risk management contracts should be conditioned on these shocks), but uncertainty remains because idiosyncratic shocks cannot be written into contracts. Unlike Diamond [1984], we do not have explicit private information, but if one believes that there are some easily contractible aggregate shocks, one should interpret the uncertainty in our model as conditional on the realization of these aggregate shocks. In addition, as in Diamond [1984], the bank's loan should be interpreted as a diversified portfolio of loans. Diversification within the bank can reduce the probability that runs and deposit defaults occur. Diversification and risk management are substitutes for capital. Without a theory of the effects of bank capital, it has not been possible to analyze the tradeoffs between these responses to uncertainty. We hope that our approach will provide a foundation for this analysis.

## **Section V: Policy Issues and Conclusion**

Our framework allows us to comment on the effects of policies such as capital requirements. We describe the trade-offs highlighted in our model that have not figured prominently in the policy debate.

### 5.1. The effects of minimum capital requirements

Minimum capital requirements specify a minimum capital to asset ratio required to enter banking or to continue to operate as a bank.<sup>19</sup> This limits the use of deposits as a commitment device. As the permissible fraction of deposits is reduced, the amount that a bank can pledge to outsiders is reduced (i.e., its effective cost of capital increases). For a bank that continues to operate, a binding capital requirement makes the bank safer, increases the banker's rent, and reduces the bank's ability to pay outside investors.

Now consider the effect of a binding current capital requirement on a bank's interaction with borrowers. If a very strict capital requirement is imposed, such as allowing no deposits at all in the future, the most that a bank can commit to pay outsiders at date 2 is the market value of its loans (pledgeability goes down from  $\max\{\overline{P}^{Safe}, \overline{P}^{Risky}\}$  to  $\frac{1+b}{2} E[\tilde{X}_2|s]$  as more capital is required). By contrast, the bank can collect its full liquidation threat immediately, and this threat is unchanged by the requirements. As a result, given a pre-existing set of claimants that have to be paid, an increase in future capital requirements makes it more likely that the banker will need to enforce the immediate liquidation threat, which will lead to liquidation if the borrower has very little cash. The liquidation threat can also increase payments extracted if the borrower has moderate cash, because future promises from the borrower have less value under the stricter capital requirements. Finally, as seen earlier, if the borrower has sufficient cash and the future liquidation threat is more valuable than the immediate one, the shortening of bank horizons induced by the changed capital requirement can reduce collections. Thus an increase in capital requirements has very diverse effects on a bank's customers, causing a "credit crunch" for the cash poor and potentially alleviating the debt burden of the cash rich. Finally, and paradoxically, by reducing the

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<sup>19</sup> See Berger et al. (1995), Kane (1995), and Benston et al. (1986) for rationales for minimum capital requirements.

bank's future ability to pledge (i.e., by increasing its cost of capital), an abrupt transition to higher capital requirements can lead to a bank run because maturing deposits may exceed what the bank can pledge while maintaining capital at required levels.

### **5.1.1 Long run effects of capital requirements**

A binding future capital requirement will reduce a bank's ability to fund itself today. The amount that a bank can raise at date 0, depends on what it can commit to pay out at date 1. If the bank relies on liquidation threats at date 1, capital requirements do not reduce pledgeability. But if

$X_1^s < \max\{\overline{P}^{Safe}, \overline{P}^{Risky}\}$ , higher capital requirements reduce the amount that can be pledged to those outside the bank. This can prevent the funding of entrepreneurs with projects with high payoffs in the more distant future.

In summary, capital requirements have subtle effects, affecting the flow of credit, and even making the bank riskier. These effects emerge only when the capital requirements are seen in the context of the functions the bank performs rather than in isolation.

### **5.2. The Effects of Deposit Insurance.**

Thus far, we have not considered the effect of deposit insurance. In practice, bank deposits below a certain amount have explicit insurance while bank deposits above that may enjoy some implicit insurance if the bank is too big to fail.

It is easy to see that at one extreme, when all depositors are insured, the insurer intervenes early, and enjoys no special powers in negotiating, deposits have no disciplinary effect. In such a situation, deposits essentially are no different from capital, and banks are safe but do not create liquidity (implying that if banks raise deposits in excess of the market value of loans, the excess will be a subsidy provided by the deposit insurer). Moreover, even if deposit insurance is fairly priced, it interferes with private contracting and weakly reduces aggregate welfare. On the other hand, when some deposits are uninsured (or when there is a positive probability that some

deposits will not be bailed out), and the insurer takes its own time coming to the bank's aid, we could get very similar effects to those in the model. Runs by uninsured depositors would still lead to some disintermediation, and this would provide some discipline. Further, if the deposit insurer has a committed policy of closing a bank when its capital is too low (and somehow enforces this commitment), then our results again follow. See Diamond [1999] for an analysis of recent Japanese banking using this approach.

We have not considered the possibility of panic-based runs (perhaps resulting from depositor fears that refinancing will not be available) or aggregate liquidity shortages which are central to the rationale for deposit insurance in Diamond-Dybvig [1983] or Holmstrom-Tirole [1997]. If these events have a positive probability of occurring, deposit insurance can have benefits that have to be traded off against its costs of reduced commitment. Firm conclusions await further research.

### **5.3. Intervention in a Crisis.**

Consider a financial crisis where a number of firms are short of cash and are threatened with liquidation by banks, while banks themselves are insolvent and face imminent runs by depositors. If the regulatory authorities want to minimize failure, how best should they target resources?

While a complete answer is not possible without parameterizing the problem more fully, our model points to some issues that are often overlooked. It is usually thought that the infusion of cash (i.e., capital) into either the industrial sector or the banking sector should make both sectors better off. This is not the case since the infusion of cash can increase (and sometimes decrease) the targeted sector's bargaining power vis a vis the other sector.

If the industrial sector gets cash, some firms will be able to avoid liquidation, and repay their loans. This may not make the banking sector any better, since it would have recovered the money anyway by liquidating. Other firms may be able to survive by committing to pay the banks more in the long run, with little effect on the banks' current state. And still other firms will be able

to take advantage of the banking sector's weakened state and short horizon, and negotiate their repayments down in return for immediate payment. This will hurt the long run viability of the banking sector. Finally, the cash infusion that goes to firms that are already cash rich will have no effect on repayments or on failures. On net, the industrial sector will definitely be made better off by the infusion, though some of it may go waste (also see Holmstrom and Tirole (1998)). The banking sector may be made worse off depending on the distribution of borrowers in the economy.

Consider now a cash (i.e., capital) infusion to the banking sector. An infusion only large enough to prevent bank runs from taking place may simply lead to the industrial sector being squeezed harder. If the infusion did not take place, banks would have to sell loans to stave off a run (or actually be run), and firms would be able to negotiate their debts down with the new creditors. The infusion helps banks just survive without selling loans, but forces them to be tough with their borrowers. Some firms will be liquidated, while others may just survive by mortgaging their future to the banks. The industrial sector could be made worse off by such an infusion. Of course, a greater cash infusion will extend bank horizons, enabling banks to use long run liquidation threats, and help the industrial sector escape liquidation without transferring excessive value to the banking sector. Thus the re-capitalization of the banking sector may have to be really large in order to have a positive influence on the industrial sector. More work is needed to quantify these effects.

#### **5.4. Conclusion**

We have presented a theory of bank capital in a model where the bank's asset side and liability side are intimately tied together. We have identified at least three effects of bank capital – on bank safety, on the bank's ability to refinance at low cost, and on the bank's ability to extract repayment from, or its willingness to liquidate, borrowers. A large number of avenues for future research have only been sketched and deserve much more detailed exploration.

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## Appendix .

### Proof of Proposition 1 (sketch)

1) If  $d_1 > \max\{\bar{P}^{Safe}, \bar{P}^{Risky}, X_1^s\}$ , pledgeable bank assets are less than the face value of deposits.

Depositors know that not enough cash can be raised to pay off all the maturing deposits, therefore they will run to seize loans (or force the bank to sell them to third parties for cash). After the run, the loans will be in the hands of depositors. The entrepreneur can make them a direct offer.

Whether they accept or reject depends on how much they can get by rejecting. Since the banker has been disintermediated, he has valuable collection skills this period at date 1, but they will dissipate by date 2. So if the depositors negotiate with the banker to act as their liquidating agent

at date 1, the banker will collect  $X_1^s$  from the entrepreneur and pocket a fee of  $\frac{(1-b)}{2} X_1^s$ ,

leaving  $\frac{(1+b)}{2} X_1^s$  for depositors. Alternatively, the depositors may prefer to wait till date 2 and

exercise their expected liquidation threat of  $bE[\tilde{X}_2 | s]$ . Thus depositors can expect to get

$\max[\frac{(1+b)}{2} X_1^s, bE[\tilde{X}_2 | s]]$  by rejecting the offer. This is the offer the entrepreneur will

make to them directly, and the banker will get cut out.

The entrepreneur has the ability to make this offer; even if he has no cash, he can liquidate himself and pay depositors  $\frac{(1+b)}{2} X_1^s$  and he can always promise  $bE[\tilde{X}_2 | s]$ . Would he prefer to not liquidate himself and take his chance with the banker? The answer is no. To avoid liquidation, he would need to offer the bank cash and future promises totaling  $X_1^s$ . But since the bank has no better ability to enforce future payments by the entrepreneur, when the entrepreneur

can avoid liquidation by the banker, he also can promise depositors  $\frac{(1+b)}{2} X_1^s$  without liquidating himself.

2)  $Max\{\bar{P}^{Safe}, \bar{P}^{Risky}\} \geq X_1^s$  only if  $E[\tilde{X}_2|s] > X_1^s$ . If the banker rejects an offer from the entrepreneur, he will simply wait till date 2 to threaten liquidation and extract cash. Liquidation at date 1 is dominated. As a result, the entrepreneur will offer  $P_1^1=0, P_2^1=X_2^H$  and the offer will be accepted. The banker will want to use a safe level of date-2 deposits as far as possible because this ensures he gets to extract  $E[\tilde{X}_2|s]$  from the entrepreneur. Let  $d_1^*$  be such that  $p^C + d_1^* = \bar{P}^{Safe}$  (if there are many  $d_1^*$  that satisfy this equality, let  $d_1^*$  be the highest). If  $\bar{P}^{Safe} < \bar{P}^{Risky}$ , then for  $d_1 > d_1^*$ , the banker will not be able to issue safe date-2 deposits and still meet the needs of investors at date 1 (since, by inspection,  $p^C + d_1$  strictly increases in  $d_1$  after an initial region where it does not change with  $d_1$ ). Once he has to issue risky date 2 deposits, funds raised at date-1 go up to meet investor claims, but funds extracted at date 2 from the entrepreneur go down from  $E[\tilde{X}_2|s]$  to  $\bar{P}^{Risky}$ . If  $\bar{P}^{Safe} \geq \bar{P}^{Risky}$  there is no need to switch to issuing risky deposits.

3a) If  $\bar{P}^{Risky} < \bar{P}^{Safe} < X_1^s$ , then the banker will liquidate when he gets more from doing so than continuing, or when he simply cannot continue even though he wants to. For a borrower to not be able to stave off liquidation, either of the following conditions must be true:

$$E(\tilde{X}_2|s) + C_1^s < X_1^s \quad (8)$$

$$\bar{P}^{Safe} + C_1^s < p_1^c + d_1 \quad (9)$$

The first condition is that the entrepreneur not have enough resources to bribe the banker. The second is that the banker cannot raise enough resources even with the entrepreneur's full co-operation to be able to commit enough to investors without liquidating. It then follows that

$C_1^{Liq} = \text{Max}[X_1^s - E(\tilde{X}_2|s), \mathbf{p}_1^c + d_1 - \bar{P}^{Safe}]$  where it should be noted that  $\mathbf{p}_1^c$  is also dependent on  $d_1$ .

3 b) We claim that  $d^{**}$  solves  $d_1 + \mathbf{p}_1^c = X_1 - \mathbf{p}_2^B$  where  $\mathbf{p}_2^B = q_2^H \frac{(1-b)}{2} X_2^H$  is the maximum rent the bank can extract at date 2 when deposits are set at the safe level.<sup>20</sup> To see why this is true, note that the bank can extract more than  $X_1^s$  only when the entrepreneur, in order to placate outside investors, makes date-2 promises whose value to the bank exceeds their current pledgeable value. Were it not for this pressure, i.e., if the entrepreneur only had to satisfy the bank, he would simply pay the bank a total of  $X_1^s$  over the two periods, and the bank would be satisfied. Therefore the question we have to ask is what is the minimum level of deposits at which the entrepreneur, in placating the outside investors, ends up overpaying. Consider an entrepreneur who has just enough cash,  $C_1^s$ , to enable the bank to meet the demands of outside investors through current cash and future promises. So  $C_1^s = \mathbf{p}_1^c + d_1 - \bar{P}^{Safe}$ . Such an entrepreneur has to make the maximum date-2 promise of  $E[\tilde{X}_2|s]$  to avoid liquidation at date 1, and hence will end up paying more than an entrepreneur with more current cash. Of course, an entrepreneur with less cash will be liquidated. The total payment by this entrepreneur to the bank is  $C_1^s + E[\tilde{X}_2|s]$ . Substituting for  $C_1^s$ , we get the total payment made by this entrepreneur to be

$\mathbf{p}_1^c + d_1 - \bar{P}^{Safe} + E[\tilde{X}_2|s]$ . Now if  $d_1 > d^{**}$ ,  $\mathbf{p}_1^c + d_1 > X_1^s - \mathbf{p}_2^B$ . Therefore, total payments are

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<sup>20</sup> If multiple  $d^{**}$  solve  $d_1 + \mathbf{p}_1^c = X_1 - \mathbf{p}_2^B$  (since the l.h.s is weakly increasing in  $d_1$  initially), we pick the highest such value.

greater than  $X_1^s - p_2^B - \bar{P}^{Safe} + E[\tilde{X}_2|s]$ . But  $p_2^B + \bar{P}^{Safe} = E[\tilde{X}_2|s]$ . Substituting, we get total payments exceeding  $X_1^s$ . It is easily shown that when  $p_1^c + d_1 < X_1^s - p_2^B$ , the amount the entrepreneur has to pay the bank in order for the bank to meet the claims of investors does not exceed  $X_1^s$ . Hence we obtain  $d^{**}$  is the solution to  $d_1 + p_1^c = X_1^s - p_2^B$ .

For  $d_1 > d^{**}$ , the entrepreneur who will overpay the most is one who can just avoid liquidation. So  $C_1^*(d_1) = p_1^c + d_1 - \bar{P}^{Safe}$ . Obviously, one with less cash will not be able to meet the needs of investors and will not overpay.<sup>21</sup> As entrepreneurs have more cash, the date-2 promise necessary to escape liquidation falls, and the rent embedded in the date-2 promise, as well as overpayment, fall. When  $C_1^s$  is high enough that the rent to the bank embedded in the date-2 promise falls below the date-1 rent the bank extracts, the entrepreneur will not overpay since he will simply offset one rent against the other. If  $P_1^2$  is the promised date-2 payment that avoids liquidation, and assuming  $bp_1^2 > X_2^L$  (only the expression for the rent changes if this is not true, and that case is easily handled), we require

$$q_2^H \frac{(1-b)}{2} P_1^2 = X_1^s - p_1^c - d_1 \quad (10)$$

The right hand side of (3) is the date-1 rent the bank expects while the left hand side is the date-2 rent. Now  $P_1^2$  is the minimum date-2 promise that will enable the entrepreneur to commit enough to the bank's investors to avoid liquidation, so that it solves

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<sup>21</sup> The banker need not always liquidate such entrepreneurs with probability 1. If the date 1 cash payment and the future promise they offer is sufficiently attractive, the bank may want to continue if it can. So it may enter the alternating offer game with capital. With probability 1/2, capital will get to make the offer and demand the bank liquidate. With probability 1/2, the bank will make the offer and offer capital its small outside option. Anticipating this, the entrepreneur will offer to pay the banker a little over  $X_1^s$  in current and future promises, the offer will be accepted half the time, and the entrepreneur will be liquidated half the time.

$$q_2^H \frac{(1-b)}{2} P_1^2 + (1-q_2^H) X_2^L + C_1^{**} = \mathbf{p}_1^c + d_1 \quad (11)$$

Substituting for  $P_1^2$  from (4) in (3), we get  $C_1^{**}$ .

3 c) The first part is similar to (3 b) and is omitted. Again, when the date-2 rent the entrepreneur has to give the bank exactly equals the date 1 rent the bank gets from liquidation, the entrepreneur does not pay more than  $X_1^s$ . So  $\bar{C}_1 = C_1^{**}$  calculated above.

4) If  $\bar{P}^{Safe} < \bar{P}^{Risky} < X_1^s$ , the bank will threaten liquidation if  $E[\tilde{X}_2|s] \leq X_1^s$ . But the promises a cash constrained entrepreneur will make do not embed a date 2 rent to the bank since

$\bar{P}^{Risky}$  (which is the most valuable promise) does not contain a rent. So the banker will not be able to extract more than  $X_1^s$  regardless of  $d_1$ . When  $E[\tilde{X}_2|s] > X_1^s$ , a low level of  $d_1$  such that  $d_1 + \mathbf{p}_1^c \leq \bar{P}^{Safe}$  will enable the bank to continue till date 2 regardless of the entrepreneur's offer and extract  $E[\tilde{X}_2|s]$ . But once deposits exceed this level, the bank will have to liquidate at date 1 if it turns down the entrepreneur's offer (since financing using the higher level of deposits inherent in  $\bar{P}^{Risky}$  gives it no extra rent, and it is better off liquidating). As a result, entrepreneurs will offer the bank cash and date-2 promises that enable the bank to get no rent to avoid liquidation, and the bank will extract no more than  $X_1^s$ .

## Lemma 2:

Proof of Lemma 2:

When  $X_2^L < \mathbf{b}X_2^H$ , it is easily checked that  $\bar{P}^{Safe} > \bar{P}^{Risky}$  iff

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We assume here that liquidation is very costly to the entrepreneur so he always makes an offer to drive the probability of liquidation to zero if he can.

$$q_2^H X_2^H < (1 - q_2^H) X_2^L \quad (12)$$

When  $X_2^L \geq bX_2^H$ ,  $\overline{P}^{Safe} > \overline{P}^{Risky}$  iff

$$(1 - q_2^H) \left( \frac{1 - b}{2} \right) X_2^L > q_2^H \left( \frac{X_2^H - X_2^L}{2} \right) \quad (13)$$

(i) If  $q_2^H X_2^H < (1 - q_2^H) X_2^L$  then  $\overline{P}^{Safe}$  is greater than  $\overline{P}^{Risky}$ .

By (12), this is certainly true when  $X_2^L < bX_2^H$ . Now consider  $X_2^L \geq bX_2^H$ . We know

$$(1 - q_2^H) X_2^L > q_2^H X_2^H \Rightarrow (1 - q_2^H) \frac{(1 - b)}{2} X_2^L > q_2^H \frac{(1 - b)}{2} X_2^H. \text{ But } X_2^L \geq bX_2^H. \text{ So}$$

$$q_2^H \frac{(1 - b)}{2} X_2^H \geq q_2^H \left( \frac{X_2^H - X_2^L}{2} \right). \text{ It follows that } (1 - q_2^H) \left( \frac{1 - b}{2} \right) X_2^L > q_2^H \left( \frac{X_2^H - X_2^L}{2} \right), \text{ hence}$$

$$\overline{P}^{Safe} \text{ is greater than } \overline{P}^{Risky}.$$

(ii) If  $X_2^L \leq q_2^H X_2^H$ , then  $\overline{P}^{Risky}$  is greater than  $\overline{P}^{Safe}$ . By inspection, inequalities (12) and (13) are

reversed when  $X_2^L \leq q_2^H X_2^H$ . Hence  $\overline{P}^{Risky}$  is greater than  $\overline{P}^{Safe}$ .

(iii) If  $X_2^L > q_2^H X_2^H \geq (1 - q_2^H) X_2^L$ , there is a  $\beta^*$  such that  $\overline{P}^{Safe} > \overline{P}^{Risky}$  iff  $b < b^*$ . The relative

size of  $\overline{P}^{Safe}$  and  $\overline{P}^{Risky}$  is unaffected by  $\beta$  when  $X_2^L < bX_2^H$ . When  $X_2^L \geq bX_2^H$ , by inspection,

there is a  $\beta'$  such that (13) holds for  $b < b'$ . Also,  $X_2^L \geq bX_2^H \Rightarrow b \leq \frac{X_2^L}{X_2^H}$ . Therefore,

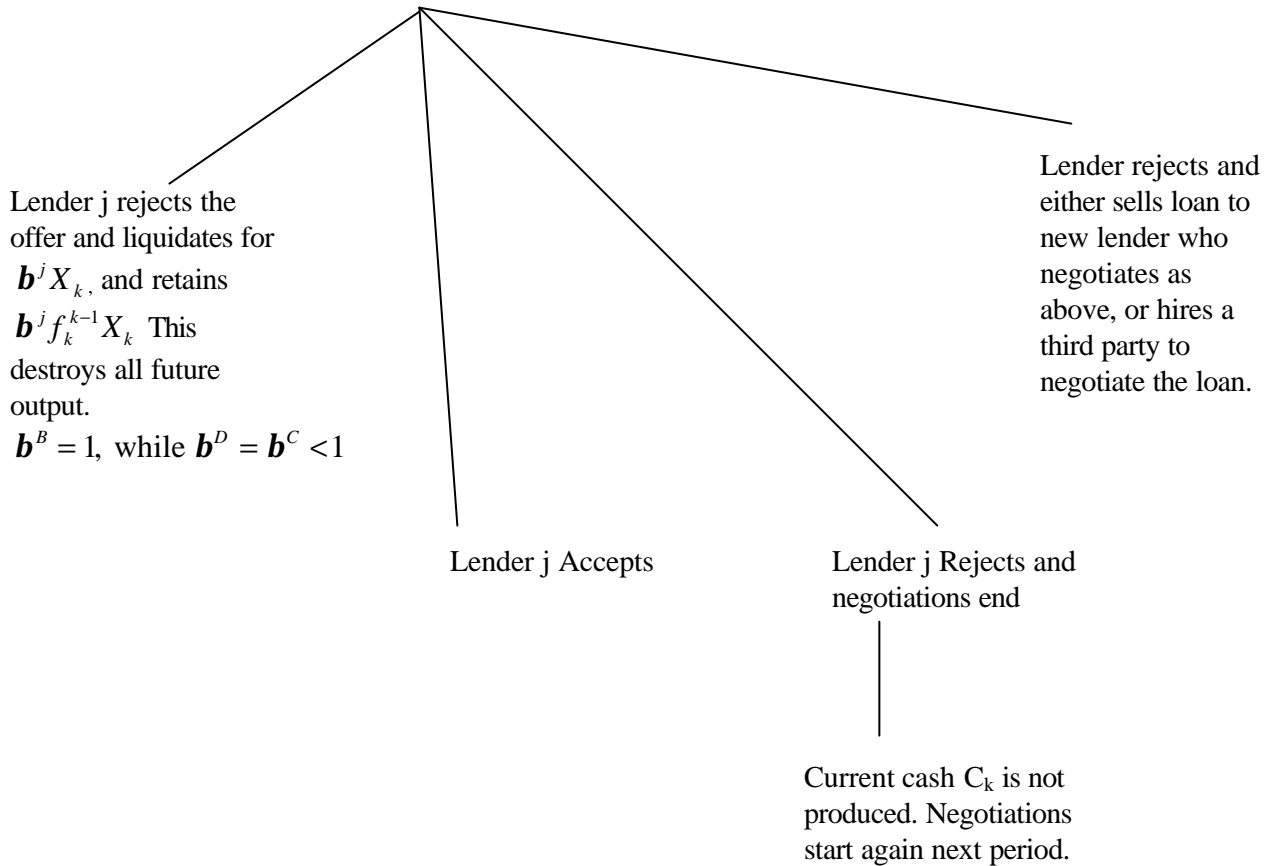
$$\overline{P}^{Safe} \text{ and } \overline{P}^{Risky} \text{ when } b < \min[b', \frac{X_2^L}{X_2^H}].$$

Q.E.D.

**Figure 1**

**Bargaining between entrepreneur and lender j  
(either j=B, j=C or j=D) at date k**

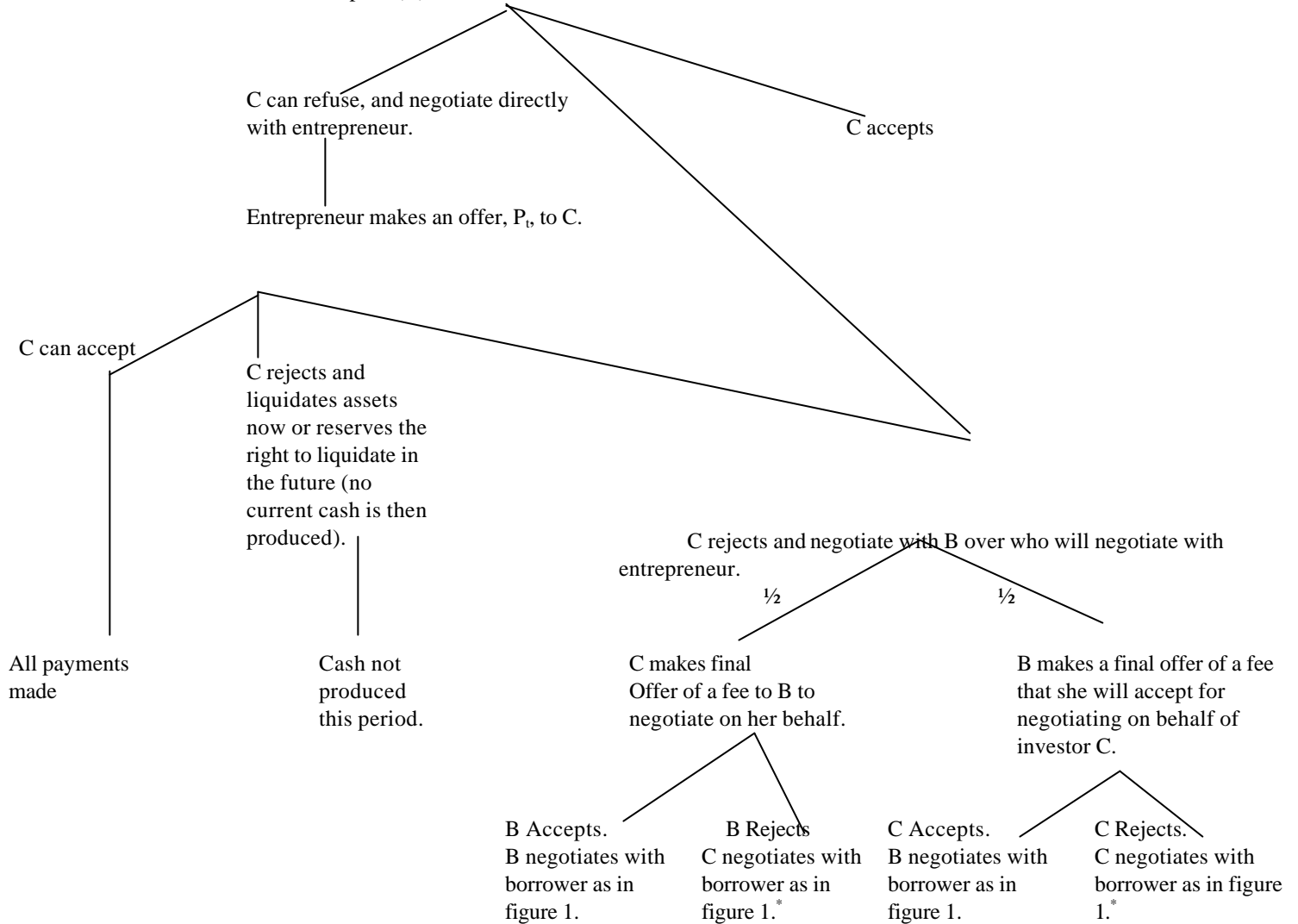
Borrower offers alternative current and future payments,  $P_t^k$ , and collateral,  $f_t^k$ , for all  $t \geq k$ . Borrower will not supply human capital this period (date k) if no agreement is reached, but will supply human capital and commit to make the alternative current payment if agreement is reached.





**Figure 2**  
**Bargaining within an intermediary.**

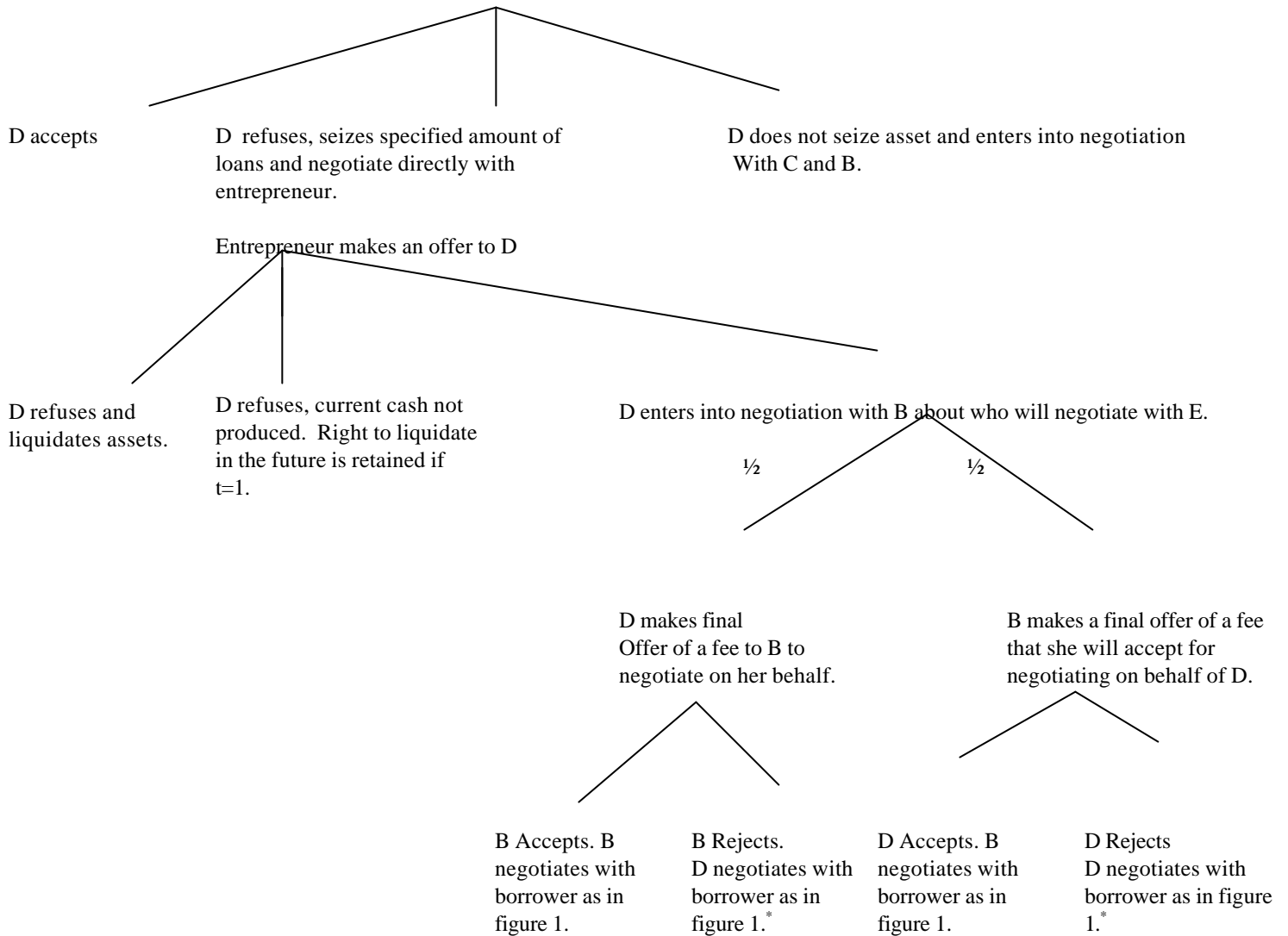
Banker (B) threatens to withdraw her human capital from the bargaining unless capital (C) makes concessions.



\* If this part of the tree is entered after C rejects the entrepreneur's offer, C now has the option of liquidating or negotiating with the entrepreneur but not of accepting the offer.

**Figure 3**  
**Bargaining with depositors.**

Banker threatens to withdraw her human capital from the bargaining unless depositors make concessions. If agreement reached, banker will make agreed payments after negotiating with entrepreneur.



\* If this part of the tree is entered after D rejects the entrepreneur's offer, D now has the option of liquidating or negotiating with the entrepreneur but not of accepting the offer.